

APPENDIX J

EVALUATION OF BEDROCK TRANSPORT CHARACTERISTICS

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TECHNICAL MEMORANDUM (Revised)

TO: Dr. Richard S. Williams, Solutia Inc.

FROM: James A. Kearley, Groundwater Services, Inc.

RE: Evaluation of Bedrock Transport Characteristics

Sauget Area 1, Sauget, Illinois

Introduction

This memorandum provides an evaluation of bedrock transport characteristics at Sauget Area 1 based on findings from the following sources: i) published studies of geology and groundwater occurrence in the American Bottoms region; ii) results of detailed field examination of rock cores collected during drilling of bedrock wells BR-G, BR-H, and BR-I; iii) results of thin section analysis of selected rock core samples from BR-G, BR-H, and BR-I; iv) results of a downhole survey at BR-I using several geophysical logging tools; and v) other observations at BR-I and a nearby piezometer, A1-19.

An earlier version of this memorandum was submitted to USEPA as part of *Response to March 2005 USEPA Comments on the DNAPL Characterization and Remediation Study, Sauget Area 1 Sites* Groundwater Services, Inc., (GSI), May 27, 2005. The memorandum has been revised to include additional data from BR-I and A1-19.

Background Information

The alluvial aquifer underlying the Sauget Area 1 sites consists primarily of silt, sand, and gravel and has a variable thickness ranging from approximately 105 to 116 feet, based on boring logs from piezometers installed in 2004 and 2005 during the DNAPL characterization and remediation study. Groundwater is present within the alluvial aquifer starting at a depth of approximately 15 to 20 ft below ground surface (bgs). The alluvial aquifer is underlain by limestone and dolomite bedrock.

Information from Published Studies Regarding Bedrock

Bedrock data from oil wells and oil test holes in the region indicate that the alluvial deposits in the American Bottoms are underlain by consolidated sedimentary rocks over 3800 feet thick, predominantly limestone and dolomite, with some sandstone and shale (Bergstrom and Walker, 1956). The bedrock immediately underlying the alluvial deposits in the American Bottoms is reported to be of Mississippian or Pennsylvanian age.

Bedrock has apparently never been an important source of water in the American Bottoms. Bergstrom and Walker, 1956 state that "no groundwater supplies are being withdrawn from bedrock formations in the American Bottoms..." and that water in the deeper bedrock is commonly too highly mineralized for use, "particularly at depths

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greater than 370 to 420 feet below ground level on the flood plain..." A groundwater development report for the East St. Louis area prepared by the Illinois State Water Survey (Schicht, 1965) states that "because of the low permeability of the bedrock formations and poor water quality with depth, the rocks do not constitute an important aquifer in the area."

The Illinois Department of Natural Resources developed an American Bottoms regional model for groundwater flow in the alluvial aquifer (Clark, 1997), and one of the assumptions used in this model is that leakage from the underlying bedrock is negligible. "There is an insufficient pressure head difference to cause significant flow between the valley fill and the indurated carbonate rocks. This assumption allows treating the bottom of the valley fill as a zero flow boundary." (Clark, 1997)

Results of Field Examination of Rock Cores from BR-G, BR-H, and BR-I

Three bedrock wells (BR-G, BR-H, and BR-I) were drilled and installed at Sauget Area 1 in the spring of 2000 to obtain data regarding bedrock properties and to collect groundwater samples from the bedrock. Attachment A-1 contains the pages from the Field Sampling Report that provide detailed description of field procedures, including core examination procedures (O'Brien & Gere, 2000, Volume 2 of 9, pp. 125 to 138).

Mud rotary drilling methods were used to drill the boreholes for BR-G, BR-H, and BR-I. At each boring, a series of telescoping PVC casings was installed, with the innermost 4-inch diameter PVC casing extending from the ground surface to a depth of approximately five feet into the top of bedrock. Bedrock coring was then conducted beneath the 4-inch diameter casing to a depth of approximately 20 feet into competent bedrock using wireline coring barrels to generate a minimum 2-inch diameter core. The rock borehole below the 4-inch diameter PVC casing was left uncased. Groundwater samples were collected from the three bedrock wells using a Grundfos RediFlow pump.

Bedrock core samples were described by the field engineer on rock classification worksheets. Descriptions included the following properties: color, rock quality, porosity, beds, thickness, contact, foliation, joints, weathering, surface, hardness, texture, grain shape, sorting, mineral components, and rock classification. Tables A-1, A-2, and A-3 present a compilation of rock classification data for cores from borings BR-G, BR-H, and BR-I, respectively. Attachment A-2 includes the handwritten rock classification worksheets prepared by the field engineer during drilling (O'Brien & Gere, 2000, Volume 2 of 9, pp. 145A-1 to 145A-75). For evaluating transport characteristics of the bedrock, the most significant of the descriptive properties are rock quality designation, porosity, joints, and weathering.

Rock Quality Designation: At BR-G, rock quality was described as excellent and/or massive from 112 to 122 ft bgs, and fair (i.e., moderately fractured) from 122 to 131.5 ft bgs. At BR-H, rock quality was described as poor (i.e., highly fractured) from 111 to 112.5 ft bgs, and excellent and/or massive from 112.5 to 132 ft bgs. At BR-I, rock quality

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was described as poor from 116 to 118 ft bgs, and sand was encountered from 118 to 120.5 ft bgs. Rotary drilling was resumed to reset the 4-inch diameter PVC well casing to a depth of approximately 124.75 ft bgs. Rock coring was then resumed, and rock quality was described as excellent and/or massive from 126.5 to 146.9 ft bgs.

The only locations with poor (i.e., highly fractured) rock were in the uppermost portions of the boreholes at BR-H and BR-I. This suggests that fluid transport in the bedrock may occur primarily in the weathered and fractured portion of the bedrock, immediately below the base of the alluvial aquifer.

<u>Porosity</u>: Rock porosity was generally described as "none" based on visual examination of the cores in the field. The rock classification worksheets do not indicate the presence of large pores, vugs, or solution cavities in the cores.

Joints and Weathering: Joints observed in individual core pieces were typically described as fine to very fine lines, sutures, or fractures, and were frequently observed to be clay-filled. Most were horizontal or sub-horizontal, but vertical or near-vertical joints were observed in some cores. Weathering or slight weathering was commonly noted on the surfaces at the top and/or bottom of the individual core pieces. A single core from BR-G, collected from 116.5 to 117 ft bgs, exhibited possible evidence of DNAPL. This core was reported to have a vertical fracture that was "slightly stained" with a "sweet odor." No evidence of DNAPL was noted in any other rock cores from BR-G, BR-H or BR-I.

Results of Thin Section Analysis of Samples from BR-G, BR-H, and BR-I

A total of thirty rock samples, ten from each borehole, were submitted to American Petrographic Services, Inc. (APS) of St. Paul, Minnesota, for thin section evaluation under a petrographic microscope. Attachment A-3 contains copies of the APS reports, which include thin section photographs (O'Brien & Gere, 2000, Volume 2 of 9, pp. 147A-1 to 147A-21). As summarized on Table A-4, all the rock samples examined by APS were determined to be limestone, dolomitic limestone, or dolomite. The thin sections were evaluated by APS for relative porosity, and, as described below, most samples were described as having low or moderate-low porosity, which is generally consistent with the visual observations made by the field engineer during rock classification.

Eighteen of the thirty rock samples evaluated were described as having low or moderate-low porosity (see Table A-4), and these samples were generally characterized as "dense" or "well cemented." Six rock samples had moderate porosity, with stylolites or dolomitized zones observed to be present. The six samples that were described as having high porosity were observed to have stylolites (two samples from BR-G), to be "dolomitized throughout" (two samples from BR-H), or to have "large cavities throughout" or "many lg. pores in dolomitized areas" (two samples from BR-I).

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Although thin section analysis did indicate several samples with high relative porosity, these samples do not appear to be representative of the rock mass as a whole. As discussed above, the rock classification worksheets prepared by the field engineer give no indication of the presence of large pores, vugs, and/or solution cavities in any of the bedrock cores.

Results of Downhole Geophysical Surveys at BR-I

On October 5, 2005, Colog conducted the following downhole surveys in BR-I: optical televiewer, acoustic televiewer, three-arm caliper, fluid temperature/conductivity, and video. Key findings of the Colog survey were as follows:

- Well Construction: BR-I has a 4-inch diameter PVC casing to 124.75 ft bgs and an open borehole from 124.75 ft bgs to total depth of 146.9 ft bgs (see Figure 5). The interior diameter of the PVC casing is approximately 3.5 inches, and the diameter of the open borehole in the bedrock is approximately 2.5 inches.
- Well Integrity: Due to the presence of an oil substance starting at approximately 114.5 ft bgs, the bottom of the PVC casing could not be observed directly using the optical televiewer or video camera. However, the integrity of the inside of the PVC casing below 114.5 ft bgs appeared to be sound based on the acoustic televiewer and caliper logs. Variations in borehole diameter observed below the casing between 124.75 ft and 126.6 ft bgs could be due to changes in lithology (i.e., harder or softer layers of rock), the presence of closely spaced fractures in this interval, and/or some degree of drilling washout immediately below the casing.
- Fractures: Within the open-hole portion of the well, a total of 42 acoustic features were observed at depths between 125.2 ft bgs and 144.4 ft bgs. These acoustic features were ranked from 1 to 5 based on a ranking system developed by USGS. Of the 42 acoustic features observed in BR-I, there were 13 features with a rank of 3 (i.e., distinct feature with open aperture). There was one feature, at a depth of approximately 137.1 ft bgs, with a rank of 4 (i.e., very distinct, wide possible interconnected fracture), and this feature was also observed on the caliper log.
- <u>DNAPL in BR-I</u>: At the time of the Colog survey, the top of DNAPL appeared to be present at a depth of approximately 114.5 ft bgs, based on optical televiewer data and an observed change in fluid conductivity.
- <u>Flow in Open-Hole Section of BR-I</u>: There was minimal variation in fluid temperature in the open-hole section of BR-I, which suggests that flow is unlikely in the open-hole section under static conditions.

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Origin of DNAPL in BR-I

The upper few feet of the bedrock is weathered. Pooled DNAPL is present in A1-19, which is located 15 feet from BR-I and is screened across the interface between the alluvial aquifer and the weathered bedrock (see Figure 5). The upper end of the open borehole at BR-I begins only a few feet below the apparent base of weathered bedrock. Although some acoustic features (i.e., fractures) were observed in the open borehole of BR-I, recovery tests indicate that the well yield of BR-I is low, at approximately 0.05 gpm. Based on these findings, the most likely explanation for the presence of DNAPL in BR-I is that the open borehole at BR-I is acting as a sump for accumulation of DNAPL that enters from the overlying alluvial aquifer and/or the upper few feet of weathered bedrock. Although the acoustic televiewer and caliper logs for BR-I did not show evidence of damage to the interior of the PVC casing, it is possible that some DNAPL could be entering the open borehole by leakage through the seal between the PVC well casing and the bedrock that the casing is seated in.

Evaluation of Transport Characteristics of the Bedrock

Published reports indicate that bedrock underlying the American Bottoms is not considered an important aquifer because of low permeability and poor water quality with depth (Schicht, 1965), and that there is an insufficient pressure head difference to cause significant flow between the alluvial aquifer and the underlying bedrock (Clark, 1997).

Results of rock core examination suggest that the upper few feet of bedrock underlying the alluvial aquifer are highly fractured. Below the weathered zone, bedrock at BR-H and BR-I is typically massive with few fractures. Bedrock at BR-G is massive in the upper ten feet (112-122 ft bgs) but was described as fair (moderately fractured) in the lower ten feet (122-131.5 ft bgs). Large pores, vugs, and/or solution cavities are not prevalent in the bedrock. There is some evidence of joints and weathering surfaces, although the joints were typically described as fine to very fine lines or sutures, and were often noted to be clay-filled.

Some acoustic features (i.e., fractures) were observed in the open borehole of BR-I, but recovery tests indicate that the well yield of BR-I is low (0.05 gpm). The most likely explanation for the presence of DNAPL in BR-I is that the open borehole is acting as a sump for accumulation of DNAPL that enters from the alluvial aquifer and/or the upper few feet of weathered bedrock.

These findings suggest that the upper few feet of the bedrock, which is weathered and fractured, is more likely to be a pathway for groundwater flow than the underlying competent bedrock.

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BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

TABLES

Table J-1:	Rock Classification Data for Boring BR-G
Table J-2:	Rock Classification Data for Boring BR-H
Table J-3:	Rock Classification Data for Boring BR-I
Table J-4:	Results of Thin Section Analysis of Bedrock Core Samples

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Table J-1 - Rock Classification Data for Boring BR-G Sauget Area 1 Sites Sauget and Cahokia, Illinois

Sample Depth	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
112 - 113.67	Light gray	Excellent, massive	None	Planar, thick	20 in.	Distinct	Planar	Faint filled fracture lines, a suture line at bottom	Exhibited at bottom, black, hard pitted	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	Trace to some white calcite?	Limestone
113.67 - 114.36	Light gray, NT	Excellent, massive	None	Planar, medium	8.25 in.	Distinct	Planar	Suture lines at top, clay filled fine fractures at bottom	Along joints	Solid	Moderate to hard	Granular, very fine to micro-granular	Rounded	Well sorted	Disseminated white specks (calcite)	Limestone
114.36 - 115.82 **	Light gray	Excellent	None	Planar, thick	17.5 in.	Distinct	Planar	Fine filled fractures at top and for ~1/2 inch thick at bottom, clay-filled; fracture at 14 inches has a rough and pitted surface	Exhibited at top and bottom	Solid	Moderate to hard	Granular to crystalline, very fine to micro	Rounded to sub-rounded	Well sorted	Disseminated white calcite?	Limestone
115.82 - 116.53 **	Light gray	Excellent, massive	None	Planar, medium	8.5 in.	Distinct	Planar	Fine filled fractures at top and bottom, clay filled; near-vertical fracture in middle	Exhibited in fractures	Solid	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	None observed	Limestone
116.53 - 117.03	Light gray	Excellent, massive	None	Planar, medium	5.75 in.	Distinct	Planar	One nearly vertical from top to bottom	Pitted dark gray surfaces at top and bottom, vertical fracture, slightly stained, sweet odor	Solid	Moderate to hard	Very fine to micro- granular/crystalline	Rounded to sub-rounded	Well sorted	Calcite	Limestone
117.03 - 118.36	Light gray	Excellent, massive	None	Planar, thick	16 inches	Distinct	Planar	Horizontal fine lines; 2.5 inches from top and at bottom	Slight, exhibited at top and bottom, dark gray and pitted	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded, angular crystals	Well sorted	Calcite?	Limestone
118.36 - 118.51 **	Light gray	Excellent, massive	None	Planar, thin	3 in.	Distinct	Planar	Horizontal to nearly horizontal filled fractures	Exhibited at top and bottom as pitted, rough surfaces	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded	Well sorted	Some calcite	Limestone
118.51 - 119.43	Light gray	Excellent, massive	None	Planar, medium	11 in.	Distinct	Planar	Horizontal wavy filled fracture line, 45° angle fracture at bottom, dark gray rough pitted surface	Slight to moderate along fracture	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded, angular crystals	Well sorted	Calcite present as small crystals	Limestone
119.43 - 120.56	Light gray	Excellent	None	Planar, thick	13.5 in.	Distinct	Planar	Generally horizontal clay-filled fractures, one near-vertical healed fracture near top	Exhibited in fractures, and at top and bottom	Solid	Moderate to hard	Very fine to micro- granular, some crystallization at top	Sub-rounded, angular crystals	Well sorted	Calcite crystals	Limestone
120.56 - 121.12 **	Light gray	Excellent, massive	None	Planar, medium	6.75 in.	Distinct	Planar	Wavy, horizontal clay-filled lines of fracturing near bottom	Exhibited at top and bottom in clay filled fractures	Solid	Moderate to hard	Very fine to micro- granular, some crystallization	Sub-rounded to sub-angular	Well sorted	Disseminated white specks (calcite)	Limestone
121.12 - 121.76	Light gray	Excellent, massive	None	Planar, medium	6.5 in.	Distinct	Planar	Nearly horizontal wavy fracture lines at top	Exhibited as clay seams at top and bottom, pitted at bottom	Solid	Moderate to hard	Very fine to micro- granular, some crystallization	Rounded to sub-rounded	Well sorted	With calcite	Limestone
122 - 122.71 **	Light gray	Fair	None	Planar, medium	8.5 in.	Distinct	Planar	Horizontal and vertical fracture lines	Slight at top and bottom	Solid	Moderate to hard	Very fine to micro- granular	Rounded	Well sorted	Some calcite	Limestone
122.71 - 123.31	Light gray	Fair	None	Planar, medium	7.25 in.	Distinct	Planar	Horizontal wavy fracture	Slight at top and bottom	-	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	A few white specks	Limestone
123.31 - 123.56	Light gray	Fair	None	Planar, thin	3 in.	Distinct	Planar	Wavy fine lines at bottom	Slight at top and bottom	Solid	Hard	Very fine to micro- granular, flaky break planes	Sub-rounded	Well sorted	Calcite	Limestone
123.56 - 123.83	Light gray	Fair	None	Planar, thin	3.25 in.	Distinct	Planar	None	Slight at top	Solid	Hard	Micro-granular	Rounded	Well sorted	-	Limestone
123.83 - 124.46 **	Light gray	Fair	None	Planar, medium	7.5 in.	Distinct	Planar	None present within; clay filled at bottom	At bottom	Solid	Hard	Micro-granular	Rounded to sub-rounded, some darker gray specks and spots	Well sorted	Calcite present	Limestone
124.46 - 124.63	Light gray	Fair	None	Planar, thin	2 in.	-	Planar	Wavy, horizontal; one clay filled vertical fracture	Along clay filled fracture at top	Solid	Moderate to hard	Micro-granular	Rounded to sub-rounded	Well sorted	Some calcite	Limestone
124.63 - 125.30 (11+ pieces)	Light gray	Fair	None	Planar, thin	~8 in. total, 11 + pieces	Distinct	Planar	Wavy fractures	None	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone

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Table J-1 - Rock Classification Data for Boring BR-G

Sauget Area 1 Sites Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
125.30 - 125.45	Light gray	Fair	None	Planar, thin	1.75 in.	Distinct	Planar	Healed vertical fracture	None observed	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
125.45 - 125.76	Light gray	Fair	None	Planar, thin	3.75 in.	Distinct	Planar	Generally horizontal wavy filled fractures, one healed fracture at 45° angle	At top, clayey	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
125.76 - 125.91	Light gray	Fair	None	Planar, thin	1.75 in.	Distinct	Planar	None observed	Top and bottom, slight	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
125.91 - 126.32 (four pieces)	Light gray	Fair	None	Planar, medium	4.9 in.	Distinct	Planar	Wavy, fine lines, clay filled	Exhibited along fractures	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
126.32 - 126.62	Light gray	Fair	None	Planar, thin	3.625 in.	Distinct	Planar	Horizontal filled fine fractures, two healed vertical fractures	Slight at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	Clay in fractures	Limestone
126.62 - 126.79	Light gray	Fair	None	Planar, thin	2 in.	Distinct	Planar	Clay-filled fractures at top and bottom	Top and bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
126.79 - 128.17 **	Light gray	Fair	None	Planar, thick	16.5 in.	Distinct	Planar	Horizontal, clayey	Slight exhibited at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
128.17 - 129.09 **	Light gray	Fair	None	Planar, medium	11 in.	Distinct	Planar	Horizontal, wavy fine fractures, clay filled	Slight at top and bottom	Solid	-	Micro-granular	-	-	Some white specks	Limestone
129.09 - 130.46	Light gray	Fair	None	Planar, thick	16.5 in.	Distinct	Planar	Many fine wavy essentially horizontal lines at top half, fewer in bottom	Slight at top and bottom, bottom dark gray and pitted	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
130.46 - 130.80	Light gray	Fair	None	Planar, medium	4.125 in.	Distinct	Planar	Fine horizontal lines	Dark gray pitted clay at top	Solid	Moderate to hard	Micro-granular	-	-	Pyrite infilling one fraction and as a 3/4 in. long X 1/4 in wide	Limestone
130.80 - 131.34 **	Light gray, some darker gray specks and splotches	Fair	None	Planar, medium	6.5 in.	Distinct	Planar	Horizontal fine lines	Slight at bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
131.34 - 131.51	Light gray	Fair	None	Planar, thin	2.0 in.	Distinct	Planar	Horizontal fine fracture	Slight at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	Some white outlines, fossils (?)	Limestone

Notes:

- 1) Rock classification worksheets for BR-G are in pp. 145A-1 to 145A-30 in Soil, Ground Water, Surface Water, Sediment, and Air Sampling Field Sampling Report, Sauget Area 1 Volume 2 of 9, O'Brien & Gere Engineers, September
- 2) ** = A portion of this core was submitted to American Petrographic Services, Inc. for visual documentation of relative porosity and for thin section evaluation under a petrographic microscope.

 3) A rock classification worksheet was not found for the following interval: 121.76-122 ft bgs.

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Table J-2 - Rock Classification Data for Boring BR-H Sauget Area 1 Sites Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
111 - 112.5 (eight pieces)	Fresh surface is med. gray to med. light gray	37%, Poor, —	None	Horizontal, breaks along clay seams range from 2-7 cm thick (very thin to thin)	Smooth	Distinct between sections	Fissile (see Note 4)	Planar, usually along horizontal lines clay within section is stylolite (wavy &), very thin to thin	Fresh	Solid (see Note 5)	Hard	Very fine (much less than 1 mm), micro- granular, occasional brachiopod fossil	Matrix too fine to tell, some inclusions are rounded to very angular	General ly very well sorted	Traces of black specks (horneblende), pyrite, possibly aragonite or calcite	Limestone, some shell fossils
112.5 - 113.81 **	Light gray, N7	Massive	None	Planar, thick	15.75 in.	Upper – broken, rounded; lower – w/ striae distinct	Planar	Stylolite at ~60° angle at top; stria upper 5 inches and lower ¾ of an inch	Slight at both ends	Solid	Hard	Micro-granular, some brachiopod fossils	Rounded, ~0.2 mm or less	Well sorted	Disseminated calcite w/ limestone matrix	Limestone
113.81 - 114.81	Light gray, N7	Massive	None	Planar, Medium-thick	12 in.	Distinct	Planar	Wavy striae starting at 7" below top and going to bottom, generally lines but up to 2 mm, darker gray	None, slight at top and bottom	Solid	Hard	Micro-granular, some brachiopod fossil	Rounded	Well sorted	Disseminated calcite?	Limestone
114.81 - 117.81 **	Med light gray, N6 in top 15.5"; light gray 15.5 to 26.75"; med gray 26.75-36"	Massive	None	Planar, thick; wavy lines	36 in.	Distinct	Planar and wavy	Wavy striae nearly vertical at top; horizontal near 27 inches from top	Top and bottom evidence	Solid	Hard	Micro-granular	Rounded	Well sorted	Disseminated white calcite? One thin black metallic line at ~15.75 in. from top	Limestone (breaks through grains at top, around grains at bottom 9 inches)
117.81 - 118.81 **	Light gray	Massive	None	One, planar, medium	10.75 in.	Distinct		Irregular break	Slight at top and bottom	Solid	Hard	Micro-granular, occasional brachiopod shell imprint	Rounded	Well sorted	Approx. ½ inch wide, band at bottom contains dull black specks, 3mm wide, pale green horizontal band @ 7.5 " from top	Limestone
118.81 - 119.10	Light gray, N7	Massive	None	Planar, thin	3.25 in.	Distinct	A few wavy lines	Planar	Slight	Solid	Hard	Micro-granular	Rounded	Well sorted	None	Limestone
119.10 - 120.31 **	Light gray, N6	Massive	None	Planar, thick	14.5 in.	Distinct	Wavy lines near top and bottom, clay filled	Planar, wavy, clay filled	Slight at top and bottom	Solid	Hard	Micro-granular	Rounded	Well sorted	Disseminated white calcite? Crystals; green specks & streaks	Limestone
120.31 - 120.62	Light gray, N7	Massive	None	Planar, thin	3.75 in.	Distinct	Wavy, horizont al to nearly vertical	Top and bottom	At top and bottom	Solid	Hard	Micro-granular	Rounded	Well sorted	Minor calcite?	Limestone
120.62 - 121.10	Light gray	Massive	None	Planar, thin	2 – 3 in.	Distinct	Wavy planar	Wavy	At top and bottom	Solid	Moderate to hard	Micro-granular	Rounded to sub-rounded	Well sorted	Calcite ? as rounded ½ nodules	Limestone

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Table J-2 - Rock Classification Data for Boring BR-H

Sauget Area 1 Sites Sauget and Cahokia, Illinois

Sample Depth (ft/bgs)	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
121.10 - 121.93 **	Light gray	Massive	None	Planar, medium	10 in.	Distinct	Horizonta I, wavy	Planar	At top and bottom	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	Calcite as rounded ½ nodules	Limestone
122.5 - 123.13 **	Light gray, N7	Excellent, massive	None	Planar, medium	10 in.	Distinct	Planar	Vertical to inclined lines, filled with clay	Top and bottom are slightly pitted and clayey	Solid	Hard	Very fine to micro- granular, flaky on broken surfaces, some brachiopod fossil impressions	Rounded	Well sorted	None observed	Limestone
123.13 - 124.42	Light gray, N7	Excellent, massive	None	Planar, thick	15.5 in.	Distinct	Planar	Fine, wavy, clay filled horizontal to inclined lines; stylolites occasionally	Slight to fresh; top and bottom exhibit pitted clayey surface	Solid	Moderate to hard	Micro-granular, <<1mm	Rounded to sub-rounded	Well sorted	None additional observed	Limestone
124.42 - 125.05	Light gray, N7	Excellent, massive	None	Planar, medium	10 in.	Distinct	Planar	Wavy, filled fracture at top	Exhibited at top and bottom; pitted clay-filled fracture	Solid	Moderate to hard	Very fine to micro- granular	Rounded	Well sorted	A few white calcite?	Limestone
125.05 - 127.51 **	Light gray, N7	Excellent, massive	None in rock; possibly in thin fractures	Planar, thick	29.5 in.	Distinct	Planar	Wavy lines in middle section and at lower end; possibly clay filled fractures, generally a much darker gray on fracture surface (N3)	Only in fractures, top and bottom	Solid	Moderate to hard	Very fine to micro- granular	Rounded	Well sorted	Pyrite on one fracture line	Limestone
127.51 - 128.99	Light gray	Excellent, massive	None, except in fractures	Planar, thick	17.75 in.	Distinct	Planar	Wavy fracture lines, clay filled pyrite in fracture @ 3inches from bottom; black and pitted in middle fracture.	None within; along larger fractures – slight	Solid	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded; some crystals angular	Well sorted	Calcite, pyrite in one fracture	Limestone
128.99 - 129.91 **	Light gray, N7	Excellent, massive	None	Planar, medium	11 in.	Distinct	Planar	Wavy filled fractures and sutures; dark gray clay filled	Along fracture lines	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded to sub-angular	Well sorted	Calcite	Limestone
129.91 - 130.64	Light gray	Excellent, massive	None	Planar, medium, one thin bed at bottom	8.75 in.	Distinct	Planar	Clay-filled, wavy planar fracture lines	Exhibited in fractures	Solid	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	-	Limestone
130.64 - 131.04	Light gray, N7	Massive	None	Planar, medium 5/8 in. thick	4.75 in., clay/shale layer at bottom	Distinct	Planar	Wavy fine fracture lines	Exhibited in clay-filled fracture	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded	Well sorted	Calcite	Limestone
131.04 - 131.87 **	Light gray	Excellent, massive	None	Planar, medium	10 in.	Distinct	Planar	None	Exhibited at top in clay-filled fractures	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone

Notes:

- 1) Rock classification worksheets for BR-H are in pp. 145A-31 to 145A-49 in Soil, Ground Water, Surface Water, Sediment, and Air Sampling Field Sampling Report, Sauget Area 1 Volume 2 of 9, O'Brien & Gere Engineers, September 2000.
- 2) ** = A portion of this core was submitted to American Petrographic Services, Inc. for visual documentation of relative porosity and for thin section evaluation under a petrographic microscope.
- 3) A rock classification worksheet was not found for the following interval: 121.93-122.5 ft bgs.
- 4) For the sample interval from 111-112.5 ft bgs, the description under Foliation had the following additional information: "Some white specks to pieces up to ½ inch long, rounded to blocky, may be calcite as they effervesce in HCI."
- 5) For the sample interval from 111-112.5 ft bgs, the description under Surface had the following additional information: "Solution at in clay at 112.5 ft below existing grade."

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Table J-3 - Rock Classification Data for Boring BR-I Sauget Area 1 Sites Sauget and Cahokia, Illinois

Sample Depth	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
111 - 113 (five pieces)	Very light gray, then light gray	Poor	Some	Planar, thin	1.5 to 3.75 in.	Distinct	Planar	Wavy fine lines nearly horizontal	Exhibited along fracture line	Solid	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	White specks	Limestone
116 - 118 (ten pieces)	Light gray	Poor	None	Planar, very thin to medium	0.125 to 4 in.	Distinct	Planar	Horizontal	None observable	Solid	Moderate to hard	Very fine to micro- granular	-	Well sorted	White specks throughout	-
118 - 120.5	The rock cla	ssification works	heet indica	tes that sand was pi	resent in this	interval.							•			
120.5 - 126.5	The rock cla	ssification works	heet indica	tes that no rock cori	ng was condi	icted from 1	20.5 to 126.	5 ft. This interval was drilled out u	using mud rotary drilling, and the	4-inch diame	eter PVC casin	g was reset				
120.0	THO TOOK GIA	ioomodiion worko	noot maloa	too that no rook oon	ing was some	20104 110111 1	20.0 10 120.	one interval was armed out o		i iiioii didiiio						
126.5 - 127.02 (five pieces)	Light olive gray	Excellent, massive	None	Planar, very thin to thin	0.25 to 2 in.	Distinct	Planar	Wavy, nearly horizontal	Slight at top and bottom of piece 2, bottom of pieces 4 & 5 dark gray & pitted	Solid	Moderate to hard	Very fine to micro- granular	Rounded to sub-rounded	Well sorted	Some white specks and nodules	Limestone
127.02 - 127.54	Light gray	Excellent	None	Planar, medium	6.25 in.	Distinct	Planar	Wavy, horizontal, clay filled	Slight, pitted surfaces at top and bottom	Solid	Moderate to hard	Very fine to micro- granular, flaky breakage	Sub-rounded to sub-angular	Well sorted	Disseminated white specks, calcite	Limestone
127.54 - 128.54 **	Light gray	Excellent	None	Planar, thick	12 in.	Distinct	Planar	Horizontal, wavy fine lines and suture lines ~2 inches from bottom	Slight, pitted surfaces at top and bottom of piece	Solid	Hard	Very fine to micro- granular	Sub-rounded to angular	Well sorted	Calcite, a few white specks	Limestone
128.54 - 129.35	Light gray	Excellent	None	Planar, medium	9.75 in.	Distinct	Planar	Very fine lines, horizontal to sub-horizontal	Pitted surface at top, dull clayey at bottom	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded to sub-angular	Well sorted	Disseminated white specks	Limestone
129.35 - 132.04	Light gray	Excellent	None	Planar, very	32.25 in.	Distinct	Planar	Planar, suture-like, horizontal,	Slight at top and bottom	Solid	Moderate	Very fine to micro-	Sub-rounded	Well	Disseminated	Limestone
**				thick				three			to hard	granular	to sub-angular	sorted	white specks	
132.04 - 132.35 (two pieces)	Light gray	Excellent	None	Planar, very thin to thin	0.75 and 3 in.	Distinct	Planar	One in center of piece 11, wavy, filled	Pitted surface on bottom of piece 11	Solid	Moderate to hard	Very fine to micro- granular	Sub-rounded to angular	Well sorted	Clay, calcite	Limestone
132.35 - 132.77	Light gray	Excellent	None	Planar, medium	5 in.	Distinct	Planar	Wavy fine lines, medium gray, N5, bands at top and bottom	N5, fine pitting in bottom of piece	Solid	Moderate to hard, dark gray bands slightly more soft than middle	Very fine to micro- granular	Rounded (dark bands), sub- rounded to sub-angular	Well sorted	Calcite	Limestone
132.77 - 133.87	Light gray	Excellent	None	Planar, thick	13 in.	Distinct	Planar	As wavy fine filled lines	Slight at top and bottom	Solid	Moderate	Very fine to micro-	Sub-rounded	Well	White specks	Limestone
132.87 - 132.97	Light gray	Excellent	None	Planar, thin	1.25 in.	Distinct	Planar	Wavy, filled fine horizontal lines	Slight at top and bottom ends	Solid	to hard Moderate to hard	granular Micro-granular	to sub-angular	sorted -	-	Limestone
132.97 - 133.99 **	Light gray	Excellent	None	Planar, thick	12.25 in.	Distinct	Planar	Few horizontal wavy fine lines	Slight at top and bottom, pitted surfaces	Solid, some darker gray shapes, possibly fossils	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
133.99 - 134.59	Light gray	Excellent	Solid	Planar, medium	7.25 in.	Distinct	Planar	As fine wavy filled horizontal lines	Slight at pitted surfaces on top and bottom	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
134.59 - 135.42 **	Light gray	Excellent	None	Planar, medium	10 in.	Distinct	Planar	None observed	Slight, pitted top surface	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	CaCO₃	Limestone
136.5 - 137.44	Light gray	Excellent	None	Planar, medium	11.25 in.	Distinct	Planar	None	Slight top and bottom	Solid	Moderate to hard	Micro-granular	Sub-rounded to sub-angular	Well sorted	CaCO ₃	Limestone

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Table J-3 - Rock Classification Data for Boring BR-I

Sauget Area 1 Sites Sauget and Cahokia, Illinois

Sample Depth	Color	Rock Quality	Porosity	Beds	Thickness	Contact	Foliation	Joints	Weathering	Surface	Hardness	Texture	Grain Shape	Sorting	Mineral Components	Rock Classification
137.44 - 137.61	Light gray	Excellent	None	Planar	2.125 in.	Distinct	Planar	Fine, wavy, horizontal filled lines	Pitted surface at top, smooth clayey (shale?) layer at bottom	Solid	Moderate to hard	Micro-granular	Sub-rounded to sub-angular	Well sorted	CaCO ₃	Limestone
137.61 - 138.05	Light gray	Excellent	None	Planar	5.25 in.	Distinct	Planar	-	Slight at top and bottom	Solid	Moderate to hard	Micro-granular	Sub-rounded to sub-angular	Well sorted	CaCO₃	Limestone
138.05 - 139.47 **	Light gray	Excellent	None	Planar, thick	17 in.	Distinct	Planar; white irregular shapes in bottom 7.5 in.	Horizontal to sub-horizontal fine wavy filled lines	Dull clay surfaces on top and bottom surfaces	Solid top 9.5 in.; small pits scattere d in bottom 7.5 in.	Moderate to hard	Micro-granular	-	Well sorted	White crystals in bottom 7.5 inches, do not effervesce in HCI	Limestone
139.47 - 141.72	Light gray	Excellent	None	Planar, thick	27 in.	Distinct	Planar	No jointing except at bottom	Thick pitted surface at bottom	Somewh at pitted in top 3.5 inches	Moderate to hard	Micro-granular	-	-	A bear-trap shape in top 5 inches has apparent pyrite in it	Limestone
141.72 - 142.03 (three pieces)	Light gray	Excellent	None	Planar	3.75 in. total, each ~1.25 in.	Distinct	Planar	Multitude of fine wavy sub- horizontal lines; slightly larger fractures separate pieces	Along fracture lines separating pieces	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
142.03 - 144.21 **	Light gray	Excellent	None	Planar, thick; gray irregular shaped blotches in top 2/3, white blotches in bottom 1/3	26.125 in.	Distinct	Planar	As wavy, fine, sub-horizontal fine lines	Slight at top and bottom ends	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	CaCO₃	Limestone
144.21 - 144.56	Light gray	Excellent	None	Planar, medium	4.25 in.	Distinct	Planar	As fine wavy lines at top	As pitted surfaces on top and bottom	Solid	Moderate to hard	Micro-granular	Rounded	Well sorted	-	Limestone
144.56 - 145.27	Light gray	Excellent	None	Planar, medium	8.5 in.	Distinct	Planar	As fine horizontal to sub- horizontal lines	Slight as pitted clay surfaces at top and bottom	Solid	Moderate to hard	Micro-granular	-	-	-	Limestone
145.27 - 145.70 **	Light gray	Excellent	None	Planar, medium	5.125 in.	Distinct	Planar	Clay filled at top, black stained and pitted on bottom	Pitted black bottom	Solid; pitted filled fracture in middle	Moderate to hard	Micro-granular	Rounded	Well sorted	Trace pyrite	Limestone
145.70 - 146.91 **	Light gray	Excellent	None	Planar, thick	14.5 in.	Distinct	Planar	One sub-horizontal, stylolite in middle	Pitted surface on top of core	Solid	Moderate to hard	Very fine to micro- granular	Rounded	Well sorted	Some faint white blotches	Limestone

Notes:

- 1) Rock classification worksheets for BR-I are in pp. 145A-50 to 145A-75 in Soil, Ground Water, Surface Water, Sediment, and Air Sampling Field Sampling Report, Sauget Area 1 Volume 2 of 9, O'Brien & Gere Engineers, September
- 2) ** = A portion of this core was submitted to American Petrographic Services, Inc. for visual documentation of relative porosity and for thin section evaluation under a petrographic microscope.
 3) Rock classification worksheets were not found for the following intervals: 113-116 ft bgs and 135.42-136.5 ft bgs.

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Table J-4 Results of Thin Section Analysis of Bedrock Core Samples Sauget Area 1 Sites, Sauget and Cahokia, Illinois

Sample Depth	Lithology	Relative	Comments
(ft bgs)		Porosity	
Well BR-G			
112.20 – 112.46	Dolomitic limestone, biosparite	Moderate	Dolomitized throughout
114.74 – 115.07	Limestone, pel-biosparite	Low	Well cemented
116.11 – 116.53	Limestone, oo-pel-biosparite	Low	Well cemented
118.36 – 118.51	Limestone, oo-pel-biosparite	High	Many stylolites
120.56 – 120.89	Limestone, pel-biosparite	Low	Few scattered interfragment pores
122.41 – 122.71	Limestone, biomicrite	Mod-Low	Dense, 2 thin stylolites
124.17 – 124.46	Limestone, oo-pel-biosparite	Low	Dense
126.79 – 127.13	Limestone, oo-pel-biosparite	Low	Dense
128.42 – 128.73	Limestone, oo-pel-biosparite	High	Concentrations of sub-parallel stylolites
130.80 – 131.10	Dolomitic limestone, biosparite	Moderate	Dolomitized zones throughout
Well BR-H			
111.83 – 112.19	Limestone, biosparite	Moderate	Some sutured stylolites
113.46 – 113.81	Limestone, biosparite	Moderate	Some crude stylolites
115.76 – 116.03	Dolomitic limestone	High	Dolomitized throughout
118.04 – 118.46	Calcitic dolostone, biosparite	High	Dolomitized throughout
119.87 – 120.29	Limestone, oo-pel-biosparite	Low	Dense sparite cement
121.43 – 121.63	Limestone, biosparite	Moderate	Some stylolite swarms
122.50 - 122.79	Limestone, biosparite	Mod-Low	One stylolite swarm
125.30 – 125.59	Limestone, oo-pel-biosparite	Mod-Low	A few pores in drusy sparry cavities
128.99 – 129.39	Limestone, pel-biosparite	Moderate	Some crude stylolites
131.04 – 131.43	Limestone, biomicrite	Low	Dense micrite matrix
Well BR-I			
127.54 – 127.92	Limestone, pel-biosparite	Low	Dense sparite cement
129.85 – 130.27	Pel-biosparite	Low	Dense, drusy sparite cement, syntaxial cement growth surrounds fossil fragments
131.27 – 131.55	Limestone, pel-biosparite	Low	Dense sparite cement
133.08 – 133.41	Limestone, pel-biomicrite	Low	Dense micrite matrix
134.59 – 135.01	Limestone, oo-pel-biosparite	Low	Dense sparite cement
137.61 – 137.84	Limestone, pel-biosparite	Low	Very dense and fine sparite cement
138.93 – 139.31	Dolostone, micro sparite	High	Large cavities throughout
142.57 – 142.87	Dolomitic limestone, biomicrite	High	Many large pores in dolomitized areas
145.27 – 145.46	Limestone, pel-micrite	Low	No visible porosity
146.63 – 146.88	Limestone, biomicrite	Low	Dense micrite matrix

Notes

- Thin section analyses conducted by American Petrographic Services and documented in pp. 147A-1 to 147A-21 in <u>Field Sampling Report, Sauget Area 1 Volume 2 of 9</u>, O'Brien & Gere Engineers, September 2000.
 A stylolite is defined as a "surface or contact, usually in carbonate rocks, that is marked by an irregular, interlocking
- 2) A stylolite is defined as a "surface or contact, usually in carbonate rocks, that is marked by an irregular, interlocking penetration of the two sides: columns, pits, and teeth-like projections on one side fit into their counterparts on the other." (Dictionary of Geological Terms, Third Edition, 1984).

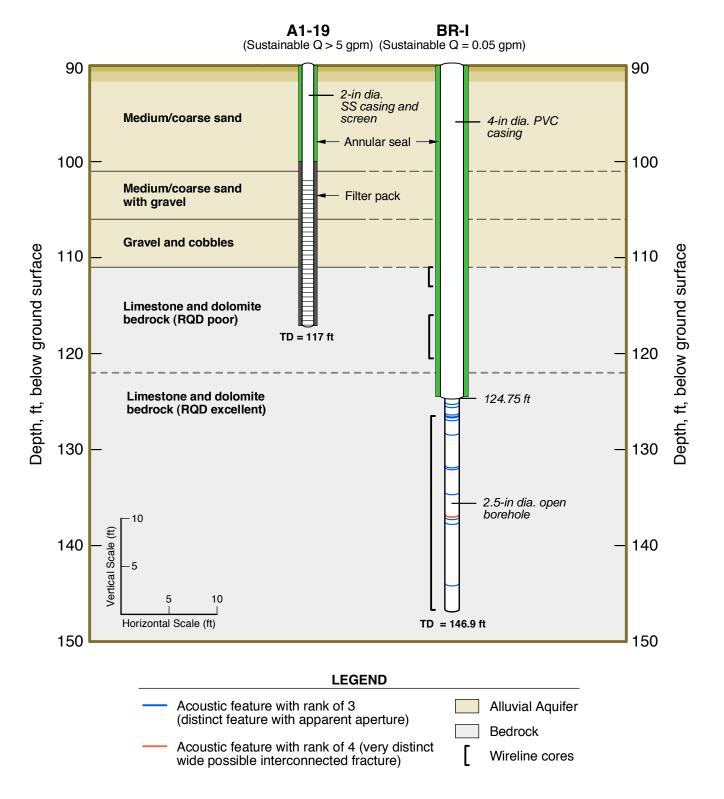


BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

FIGURE

Figure J-1 Detailed Cross Section at BR-I



Notes: 1) During drilling of BR-I, a 4-inch diameter PVC casing was installed and grouted in place, and wireline cores were collected from 111-113 ft and 116-120.5 ft bgs. Sand was observed in the wireline core collected from 118-120.5 ft bgs. The 4-inch diameter PVC casing was then removed and re-set to a depth of approximately 124.75 ft bgs.

- 2) Acoustic features were identified in an acoustic televiewer survey conducted by Colog in October 2005.
- 3) RQD = Rock Quality Designation

GROUNDWATER
SERVICES, INC.

Scale:	As Shown	FIGUE	RE J-1
Revised:		Aprv'd By:	
Issued:	08/28/06	Chk'd By: J	٩K
GSI Job N	°. G-2876	Drawn By: D	LB

DETAILED CROSS-SECTION AT BR-I From 90 to 150 ft Below Grade

Sauget Area 1 Sauget and Cahokia, Illinois



BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENTS

Attachment J-1	Description of Field Procedures
Attachment J-2	Rock Classification Worksheets
Attachment J-3	Thin Section Analysis Reports



BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENT J-1 - DESCRIPTION OF FIELD PROCEDURES

Description of Field Procedures

(Source: pages 125 to 138 from Volume 2 of Field Sampling Report, O'Brien & Gere, September 2000)

3.10. Bedrock Ground Water Sampling

3.10.1. Rationale/Design

As directed by USEPA Region V, three bedrock wells were installed in Sites G, H, and I in order to evaluate the vertical extent of organic and inorganic constituents migrating away from these sites. Locations for the bedrock wells were based on the shallow ground water concentration high plume estimated by Ecology and Environment (1998). Telescoping surface casings were installed in order to minimize carry-down of site-related constituents during ground water sample collection and vertical migration of site-related constituents after completion of sampling.

Bedrock was cored to a depth of 20 feet below the telescoping casing. Cores were digitally photographed (Section 3.10.4.6) in color against a scale and evaluated for porosity by examination and petrographic thin sections (Section 3.10.4.5). A ground water sample was collected from each core hole.

Number of Ground Water Samples

3

Analyses:

Cyanide	USEPA Method 9010B
Dioxin	USEPA Method 8290
Herbicides	USEPA Method 8151A
Mercury	USEPA Method 7470A
Metals	USEPA Method 6010B
PCBs	USEPA Method 680
Pesticides	USEPA Method 8081A
SVOCs	USEPA Method 8270C
VOCs	USEPA Method 8260B

Sampling locations were selected in the field with the concurrence of USEPA Region V or its designee.

3.10.2. QA/QC Samples

QA/QC samples consisted of the following:

- one duplicate per 10, or fraction of 10, environmental samples collected
- one MS/MSD per 20, or fraction of 20, environmental samples collected or one MS/MSD every three working days, whichever was sooner

- one equipment blank (or field blank) per 10, or fraction of 10, environmental samples collected unless dedicated or disposable sampling equipment was used to collect samples
- one trip blank per sample cooler containing environmental samples for VOC analysis that was shipped.

QA/QC samples were submitted for analysis and analyzed for the same parameters as the investigative samples, as applicable. Duplicate samples were collected to measure consistency of field sampling technique. MS/MSD samples were collected to measure laboratory QC procedures. Equipment blanks were collected to measure the effectiveness of field decontamination procedures. Trip blanks were submitted to indicate cross-contamination of VOCs during shipment.

3.10.3. Field Procedures

Prior to performing field work, a Preparatory Inspection Meeting attended by a representative of each of the interested parties was held (meeting forms included as Section 3.10.4.2). Mud rotary drilling methods were used to drill the boreholes to set the telescoping casing and to drill five feet into the top of bedrock. Four change orders were implemented to enhance the bedrock sampling task:

- 1. Prevent/minimize drilling fluids from entering the four-inch casing
- 2. Redrill the four-inch casing at Site I due to upper bedrock zone
- 3. Install 18-inch casing at Site G to prevent/minimize loss of drill mud material
- 4. Extend eight-inch casing at Site G (Section 3.10.4.X).

Site G – Twenty-inch, temporary surface casing, approximately 10-feet below existing grade; 18-inch-ID casing set at 19 feet below existing grade to seal off large rubble in fill; 12-inch-ID casing set at 31.5 feet below existing grade, approximately five feet below fill; eight-inch-ID casing set at 71 feet below existing grade, approximately 45 feet below fill; four-inch-ID casing set at 112 feet below existing grade, approximately six feet into bedrock.

Site H - Twelve-inch-ID casing set at 31.5 feet below existing grade, approximately 5.5 feet below fill; eight-inch-ID casing set at 45.25 feet below grade, approximately 19 feet below fill; four-inch-ID casing set at 109.5 feet below existing grade, approximately 4.5 feet into bedrock.

Site I — Twelve-inch-ID casing set at 32.5 feet below existing grade, approximately 5.5 feet below fill; 12-inch-ID casing set at 53 feet below existing grade, approximately 26 feet below fill; four-inch-ID casing set

at 125.5 feet below existing grade, approximately 6.5 feet into bedrock. An upper rock layer was encountered at approximately 105 feet below existing grade. This rock layer was approximately 6.5 feet thick with loose sand below; hence, through review with Solutia representatives, the first four-inch casing was removed and reset at 125.5 feet.

Coring was accomplished using wireline coring barrels to generate a two-inch minimum core. Coring continued for 20 feet into the competent bedrock. Core samples were photographed (Section 3.10.4.6) and described on rock classification work sheets (Section 3.10.4.4). Descriptions followed the procedures outlined below. After coring was completed, a ground water sample was collected from the bedrock core hole. Sampling was accomplished using a Grundfos RediflowTM pump, control box, and electrical generator. Sampling was accomplished following applicable procedures outlined in Section 3.7.3. A PID, fourgas meter, and a RAM were used to monitor these activities.

Once sample collection was completed, the pump and tubing were pulled. The tubing was placed into a plastic trash bag and disposed in the general waste dumpster. An expandable seal, locking plug was installed in the top of the four-inch casing. The borehole will be abandoned by filling the annular space with a cement and bentonite grout from bottom to top. The surface top two feet will be restored with soil and seeded. The drill rig was moved to the decontamination station and steam cleaned. Solids were placed into a container for transport to the Judith Lane storage site. Drilling fluids were contained in 55-gallon drums prior to disposal.

Sampling Equipment Decontamination -

- Brush-wash reusable sampling equipment in a bucket or tub using a trisodium phosphate (TSP) or other commercial detergent solution (two pounds of TSP per 10 gallons of clean water). Completely brush the entire exterior surface of the article undergoing decontamination. Wash interior wetted surfaces as required. Rinse the item with copious quantities of potable water, followed by a distilled water rinse.
- Rinse reusable sampling equipment used to collect environmental media for metals analysis in a dilute nitric acid solution, following by a distilled water rinse.
- Air-dry sampling equipment on a clean, nonplastic surface in a
 well-ventilated, uncontaminated environment. If the sampling
 device is not to be used immediately, wrap it in aluminum foil
 and place it in a plastic bag or storage container.
- Contain rinse waters in a plastic tub or bucket with a lid. Empty
 the contents of this tub daily into a 55-gallon drum located at the
 IDW storage area.

Decontamination waters were placed into a temporary container and transported to the wastewater disposal container. IDW, such as disposable gloves, paper towels, plastic sheeting, and TyvekTM suits (if worn), were containerized and taken to the Judith Lane waste staging area prior to disposal.

Method – The geologists and geotechnical engineers wrote their description of rock samples with a consistent format. The order and presentation of selection of data are presented below.

The order in which the rock description was documented following the order presented below.

Order of a	Description	for L	.itholoav
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1.	Color	9.	Weathering
2.	Rock quality	10.	Surface
3.	Porosity	11.	Hardness
4.	Beds	12.	Texture
5.	Thickness	13.	Grain shape
6.	Contact	14.	Sorting
7.	Foliation	15.	Mineral components
8.	Joints	16.	Rock classification

Abbreviations of the descriptions conformed to the standard abbreviation list. This list is presented below. A word that is not on this list was spelled out. An initial capital letter was used for each rock type. Capital letters are for formation names and rock types.

Punctuation was also standardized. The following convention was used for punctuation:

- comma after each item of description
- semicolon between each rock-type description
- no full stops (periods)

In addition, remarks such as A/A ("as above"), same as above, see above, or same are undesirable.

Log Order of Presentation and Selection – The following order was used to present information on the log:

1. Color

Color (from Munsell Color Chart) of logged interval or mass (sample).

2. Rock Quality

The rock quality designation (%RQD) is computed in the following way:

 $%ROD = 100 \times [length of core in pieces \ge 4'] +$ [hole length drilled or attempted (cored)]

Guidelines:

Measure from the center of natural breaks.

- Exclude joints that dip within five degrees of core axis.
- Exclude drill breaks. (See criteria for identification of drill breaks.)
- Do not calculate RQD for soft semi-indurate rock or severely weathered rock. ("Weathering" is addressed below.)

Scale:

90	-	100	Excellent	Massive
75	-	90	Good	Lightly fractured
50	-	75	Fair	Moderately fractured
25		50		Highly fractured
0	-	25		Sheared

It is appropriate to think of ROD in conditions of equal effect; that is, group the RQD ranges as equivalent to rock type, structural domain, shear zones, and so forth.

Criteria for Identifying Drilling Breaks:

- A rough, brittle surface with fresh cleavage planes in individual rock minerals indicates an artificial fracture.
- A generally smooth or somewhat weathered surface with soft coating or infilling materials such as tale, gypsum, chlorite, mica, or calcite obviously indicates a natural discontinuity.
- In rocks showing foliation, cleavage, or bedding, it may be difficult to distinguish between natural discontinuities and artificial fractures when these are parallel with the incipient planes of weakness. If drilling has been carried out carefully, then the questionable breaks should be counted as natural features to make the conservative assumption.
- Depending on the drilling equipment, part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock

types, it may be difficult to decide if the resulting rounded surfaces are present natural or artificial features. When in doubt, the conservative assumption should be made; that is, assume that they are natural.

• It is appropriate to keep a separate record of the frequency of artificial fractures for assessing the possible influence of blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

The occurrence of impurities is qualified with the following terms:

 consolidated, unconsolidated, semi-consolidated round, sub-round, sub-angular, angular, ellipsoidal, spherical.

Masses	Brecciated	Trace remnants
Pockets	Chaotically intermixed	Disseminated throughout matrix
Nodules	Fine wispy layers	Scattered
Blebs	Stringers	Streaks or specks
Lenses	Subtle network	Narrow zones
Oolites	Chicken wire pattern	
Zones	Dendritic	
Transitions		

3. Porosity

Use the following descriptions:

• none, medium, moderate, very, pinhole porosity, visual porosity.

4. Beds

Bedding, horizontal or inclined:

- planar
- mylonitic
- folded
- contorted
- wavy banding.

Bedding, beds, cleavage, and foliation:

Very thin	1 – 3 cm (0.4 - 1")
Thin	3 - 10 cm (1 - 4")
Medium	10 - 30 cm (4" - 1")
Thick	30 - 100 cm (1' - 3')
Very thick	>100 cm (>3')

Lamina:

- laminated: 0.3 1 cm (0.4 0.1)
- thinly laminated: <0.3 cm (<0.4")

5. Thickness, Laminations, Lamella, Seams

- smooth
- broken
- irregular
- convoluted
- up/down criteria

6. Contact

- distinct
- vague
- gradational

7. Foliation

- fissile (planar splitting)
- nonfissile

8. Joints

Planar	Irregular break	 Infilled with
Parting	Scalloped	Healed fracture
Planes	Conchoidal	 Mylonitic

Spacing:

Very thin	1 – 3 cm (0.4 - 1")
Thin	3 – 10 cm (1 - 4")
Medium	10 - 30 cm (4" - 1")
Thick	30 - 100 cm (1' - 3')
Very thick	>100 cm (>3')

9. Weathering

Fresh

Rock fresh; crystals or grains bright; a few joints may show slight staining; crystalline rocks ring if struck with a hammer.

Slight

Rock generally fresh; joints stained and may show clay filling if open; staining may extend into rock fabric adjacent to weathered planes; if present, feldspars may be dull and discolored; crystalline rocks ring if struck with hammer.

Moderate

Except for quartz, most of the rock mass shows discoloration and weathering; most feldspar is dull and discolored and kaolinitization

(alteration to clay minerals) is common; rock gives a dull sound if struck with hammer; rock shows overall loss of strength; potions may be removed with a geologist's pick.

Severe

All minerals except quartz discolored or stained; rock fabric still discernible; intergranular or intercrystalline disassociation virtually complete; internal structure essentially that of soil; fragments of strong rock may remain; may be called saprolite.

Complete

Rock is decomposed to a soil; fabric not discernible or only barely discernible; quartz may remain as dikes or stringers.

10. Surface Solid

Contains no voids.

Pitted

Small voids generally restricted to joint surfaces, bedding planes, or other surfaces which provide access for attacking fluids.

Vuggy

Use restricted to solution voids in carbonate rocks and hydrothermally altered rocks; voids may be found throughout the rock face; voids up to nine-inch diameter.

Vesicular

Use restricted to voids in igneous (occasionally metamorphic) rocks, void origin usually due to gas bubbles; voids up to three-inch average diameter.

Cavernous

Applicable in any rock; voids and channels greater than nine-inch average diameter; voids large enough to cause serious leakage or structural problems.

11. Hardness

The following scale (not to be confused with Moh's scale for hardness of minerals) is used to a rock:

Very Hard

Cannot be scratched with knife or sharp pick; breaking of hand specimens require several hard blows of geologist's pick.

Hard

Can be scratched with knife or pick only with difficulty; hard blow of hammer required to detach hand specimen.

Moderately

Can be scratched with knife or pick; gouges or groves to 1/8 inch deep can be excavated by

hard blow of point of geologist's pick; hand specimens can be detached by moderate blow.

Medium

Can be grooved or gouged 1/16 inch deep by firm pressure on knife or pick point; can be excavated in small chips to pieces about one inch maximum size by hard blows of the point of a geologist's pick.

Soft

Can be gouged or grooved readily with knife or pick point; can be excavated in chips to pieces several inches in size by moderate blows of a pick point; small thin pieces can be broken by finger pressure.

Very Soft

Can be carved with knife; can be excavated readily with point of pick; pieces one inch or more in thickness can be broken by finger pressure; can be scratched readily by fingernail.

12. Texture

American Geological Institute data sheets:

- fine = < 1 mm
- medium = 1.5 mm
- coarse = >5 mm

13. Grain Shape

very angular

- angular
- subangular
- subrounded
- rounded
- well-rounded

14. Sorting (For Sedimentary Rocks)

very well sorted

- well sorted (poorly graded)
- moderately sorted
- poorly sorted (well graded)
- very poorly sorted

15. Mineral Components

16. Rock Classification

American Geological Institute data sheets:

Accepted Abbreviations -

	chalcedonyCHAL
A	chalkCHK
about ABT	chertCHT
aboveABV	chitinCHIT
abundantABDT	chloriteCHL
accumulation ACCUM	CHIONECHI TO
acicularACIC	chloriticCHLTC
aggregate AGG	clasticCLAS
agglomerateAGLM	clayCLY
algaeALG	claystoneCLYST
alteredALT	cleanCLN
amorphousAMOR	clearCLR
amountAMT	cleavageCLV
angular ANG	clusterCLS
anhedralANHED	coalCOAL
anhydriteANHY	coarseC
anhydriticANHYDRIC	cobble CBL
apparentAPR	colorCOL
appears APRS	commonCOM
approximateAPROX	compactCOMP
aragoniteARAG	conchoidalCONCH
arenaceousAREN	concentricCNCN
argillaceous ARG	conodontCONO
arkoseARK	conglomerateCGL
asphaltASPH	contactCONT
at@	contortedCONTRT
averageAV	coquinaCOQ
640:000	coveredCOV
В	creamCRM
bandBND	crenelated CREN
bandedBNDD	crevice CREV
bariteBAR	crinkled CRNK
basaltBAS	crinoid CRIN
bedBED	crossbeddedXBEDD
beddedBEDD	crosslaminated XLAM
beddingBEDG	cross-stratified XSTRAT
bentoniteBENT	cryptocrystalline CRPXLN
biotiteBIOT	cryptograined CRPGR
bitumenBIT	crystalXL
black BLK	crystailineXLN
bleeding BLDG	cuttings CTGS
blockyBLKY	_
botryoidaBTRI	D
bottomBTM	dark DK
boulderBLDR	deadDD
brachiopod BRAC	debrisDEB
brachiopod BPEC	degreeDEGR
breccia BREC brittleBRIT	dendritic DEND
	denseDNS
brightBRI	determineDTRM
brokenBRKN	detritalDTRL
brownBRN	diameter DIAM
bryozoaBRY	diatomsDIAT
_	differenceDIF
C _A	disseminated DISM
calciteCA	dolocast DOLC
calcareousCALC	dolomiteDOL
carbonaceous CARB	dolomitic
cavernousCAV	dolomoidDOLM
caving CVG	druseyDRSY
cement CMT	uluseybixs i
centerCNTR	
cephalopod CEPH	
124	

E	greenGREEN
earthyETHY	grittyGRTY
	gypsumGYP
echinoidECH	
eliptical ELIP	gypsiferous GYPS
elongate ELNG	
embeddedEMBEDD	H
enlarged ENL	hardHD
	heavyHVY
epidoteEP	hematite HEM
equivalent EQUIV	
euhedralEUHED	highHI
evaporiticEVAP	horizontal HOR
exposeEXP	homblende HBD
extrusive EXTRU	hydrocarbonHYDC
extrusive EXTRO	nydrocarbon
F	1
facetedFAC	igneousIG
faintFNT	imbedded IMBEDD
	impregnatedIMPRG
fairR	
faultFLT	impressionsIMP
faunaFAU	includedINCL
feldsparFELS	inclusionINCLSN
ferruginousFE	increase INCR
fibrousFIB	indistinctIND
	interbeddedINTBEDD
figuredFIG	
fine,-lyF	intercrystalline INTXLN
fissileFISS	intergranular INTGRAN
flaggyFLGY	intergrownINTGWN
flake,-yFLK,-Y	interlaminated INTLAM
HdN0,-yFLN,-E	interstitialINTSTL
flinty FLTY	
floatingFLTG	intervalINTVL
fluorescence FLUOR	intraformational ÎNTRM
foliated, -ionFOL	intrusionINTR
	invetebrate INVRTB
foraminifera FORAM	
formationFMTN	ironFE
fossil FOSS	iron Oxides FE-OX
fossiliferous FOSSIF	ironstoneFE-ST
fracture,-ed FRAC	irregular IREG
	iridescentIRID
fragmentFRAG	BIGGGGGIT IIIIIIIIIIIIIIIIIIIIIIIIIIIIII
freshFRSH	•
friable FRI	J
frostedFROS	jasperJASP
fusilinidFUS	jointedJTD
Tuber	jointingJTG
•	
G	jointsJTS
gabroGAB	
gastropod GAST	K
glassy GL	kaolin,-iteKAOL
glauconiteGLAUC	•
	L
globularGLOB	
gloss GLOS	laminatedLAM
gneissGN	largeLRG
goodG	lavenderLAV
gradeGRD	layerLYR
	leached LCHD
gradingGRDG	
grainGRN	ledgeLDG
graniteGRNT	lenticularLENT
granularGRAN	lightLT
granule GRNL	ligniteLIG
	limestoneLS
graptoliteGRAP	
gravelGVL	limonite LMNT
gray GRY	limyLMY
graywackeGYWKE	lithicLITH
	lithographicLITHG
greasyGRSY	

· · · · · · · · · · · · · · · · · · ·	
littleLTL	pearlPRL
longLONG	pebblePBL
IOOSELSE	pegmatitePEG
lowerLOW	pelecypodPLCY
lumpyLMPY	pelletPEL
lusterLSTR	permeabilityPERM
the property of the same of th	petroleumPET
M	phosphatePHOS
macro-fossil MACFOS	pinkPNK
magneticMAGN	pinpoint porosityPPP
magnetite MAG	pisolitePISO
marlML	pittedPIT
marlstone MRLST	plagioclasePLAG
maroonMAR	plant fossils PL FOS
massive MASS	plasticPLAS
materialMAT	platyPLTY
matrixMTX	polishPOL
maximum MAX	poorPR
medium M	porcelaneousPORC
member MBR	porosityPOR
metamorphic METAM	porphyryPORPH
micaMIC	possiblePOS
micaceousMICAC	predominantPRED
microcrystalline MICXLN	preservedPRES
microfossil MICFOS	primaryPRIM
micrograined MICGR	prismaticPRIS
micromicaceousMMIC	probablyPROB
middleMID	prominentPROM pseudoPSDO
mineral MNRL	pseudo PURP
minimumMIN	purplePURP pyritePYR
minorMNR	pyrobitumen PYRBIT
minuteMNUT	pyroclasticPYRCLAS
moderateMOD	pyrociastic
mollusca MOL	Q
mottledMOT	quartzQTZ
mudstone MDST	quartziteQTZT
muscoviteMUSC	quartzitic QTZTC
N	quartzoseQTZS
nacreousNAC	
noduleNOD	R
numerousNUM	radiateRAD
Turnerous	rangeRNG
0	randomRAND
objectOBJ	rareRR
occasionalOCC	redR
ocherOCH	regularREG
odorODOR	remainsRMN
oilOIL	replacedRPL
oliveOLV	residueRESD
ooliticOOL	resinousRSNS
opaqueOPG	rhombohedralRHMB-L
oppositeOPP	rockRK
orangeORNG	roundRND
organicORG	roundedRNDD
orthoclaseORTH	rubblyRBLY
ostracodOST	rustyRST
oxidizedOX	•
	S SALT
P	salt SALT saccharoidal SACC
patchyPCHY	saccharoldal
partPT	sandSD
partingPTG	SDIRG

sandstonéSS
sandySDY
saturatedSAT
scalesSC
scarceSCS
scatteredSCAT
schistSCH
scolecondonts SCOL
secondarySEC
secondary
sedimentSED
selenite SEL
sericiteSER
severeSEV
shale,-lySH,SHY
siderite SID
sidente
silicaSIL
siliceousSILIC
silkySLKY
slitSLT
siltstoneSLTST
sizeSZ
slickensidedSLKS
slightSL
Silgit
smallS
smoothSMTH
softSFT
solubleSOLB
solutionSOL
sortSRT
speck SPCK
sphalerite SPHAL
spherulesSPH
spiculeSPIC
splintery SPL
spongeSPG
sporeSPR
spotSP
stainSTN
stained STND
staining STNG
staining STNG
stippled STIP
strataSTRAT
streak STR
striatedSTRI
stringerSTRG
stromatoparoids STROM
structureSTRUC
styoliteSTYL
subangularSUBANG
subhedralSUBHED
sucroseSUC

sulphurSULF surfaceSURF
tabular TAB texture TEX thick THK thin THN through THRU tight TT tourmaline TOUR trace TR transparent TRNSP trilobite TRILO tripolitic TRIP tubular TUB
unconformity UNCONF unconsolidatedUNCONS upper
v variable VAR varicolored VCOL variegated VGTD varved VRVD vein VRTB very VES vitreous VIT volcanics VOLC vug,-gy,-ular VAR
water WTR wavy WVY waxy WXY weather WTHR weathered WTHRD white WH with W/
Y yellowYEL
z zoneZN

3.10.4. Documentation

Four change orders are included in Section 3.10.4.1. Field logs generated are included in Record Book No. 1 (Appendix D). Figure 1 depicts bedrock ground water sampling locations. Ground water sampling logs are included in Section 3.10.4.3. Rock classification work sheets are included in Section 3.10.4.4. A petrographic thin section report is included in Section 3.10.4.5. Digital photographs of rock cores are included in Section 3.10.4.6. Chain-of-custody forms are included in Section 3.10.4.7.

Documentation for this task continues on the next page.



BEDROCK TRANSPORT EVALUATION

Sauget Area 1, Sauget and Cahokia, Illinois

ATTACHMENT J-2 - ROCK CLASSIFICATION WORKSHEETS

Rock Classification Worksheets

(Source: pages 145A-1 to 145A-75 from Volume 2 of Field Sampling Report, O'Brien & Gere, September 2000)

Sauget Area 1	
Rock Classification	worksheet
Site of	quee. #1:20ing 112-113.67
Color:	light one
	sign of Surg
Rock Quality:	excellent, museur
	research, process
Porosity:	none
•	
Beds:	stana man thick
	flanar, solay, thick
Thickness:	20inekes
Contact:	distinct
Foliation:	glanes
Joints:	faint filled propers line, a sulice lay at totom
Weathering:	exhibited at bottom bleet hard atted
Surface:	
Surface:	solii
Hardness:	
raiuness.	moderate to have
Texture:	
r Catalic.	musagranilar
Grain Shape:	rounded
э. а э.ларс.	11441111
Sorting:	wellsorted
	wayer
Mineral components:	Action to the second of
Mineral components:	white cateste husto come detett calcile?
Rock Classification:	
v.womodium,	emestone

Sauget Area 1	
Rock Classification	worksheet
	v o sterile at
Lity Ju	ice 2, 8.25 cuche 113.67-114.36
Color:	Kenteray, NT
Pook Oveliber	
Rock Quality:	excellent, messeens
Porosity:	
orosity.	ioni
Beds:	
	places, may that medium
Thickness:	+
, maniess.	5.25 rehy
Contact:	distinct
	Augury)
Foliation:	
	Plane
	7
Joints:	0.4.0 110 1131
	seture lever at top; chapilled in practices at
	- Carles
Weathering:	allans and the
	along joints
Surface:	Sulul
Hardness:	moderate to feet
exture:	sandel
	Jan and a mass
Grain Shape:	saudiel
iorting:	well sorled
lineral components:	despourate akito specka (calcite)
	C - The series of the contraction
lock Classification:	Une fort

Sauget Area 1	
Rock Classification	worksheet
100	. –
	1805, 17.5 ineper , 1.14.36-115.82
Color:	light circle
Rock Quality:	Ovietlant
Porosity:	1ane
Beds:	planer which
Thickness:	26 Juck 17.5
Contact:	distinct
Foliation:	Ala- 01
_	Jane Commission of the Commiss
Joints:	fine filled greatures at top end for # 7 1/2 ench
,	Mark of bottom con 1 od & ligation of 14 which
h	as a rough with willing
Weathering:	ashibited it too ton the stam
Surface:	solid
Hardness:	moderate to hard
Texture:	quarula to engetalling, very firsto mero
Grain Shape:	sounded to subsounded;
Sorting:	well sorted
Mineral components:	Leses nent dukite calcile!
Rock Classification:	Vinestoni

Sauget Area 1	
Rock Classification w	vorksheet
0.	4
Silvery	Proceet: 85in, 11589-116,53
Color:	listones
Rock Quality:	exellent maderie
	,
Porosity:	hone
Beds:	slaver medium
	James June
Thickness:	
I NICKNESS.	8.5 inches
Contact:	distinct
Curract.	dellas
Foliation:	
onation.	france
Joints:	1140 DE 170 11 1 E 10 11-11
,	filed; and real vertical fraction in the
Weathering:	12/12/10 1 11 11 11
Yveauleinig.	exhibited in fractures
	<i>P</i>
Surface:	solid
0011000.	Succe
Hardness:	moderate to hard
	machine vorance
Texture:	arely lines to marked any last
	very fine to mor granular
Grain Shape:	sounded to subsounded
'	Mariago FU , MUNOUNDEN
Sorting:	well serted
,	Marie Carret
Mineral components:	none observed
•	The contract of the special sp
Rock Classification:	Amertino,
	MINIGEN

Sauget Area 1	
Rock Classification	worksheet
Stexy	
Color:	light ray 116.53-117.03
Rock Quality:	excellent, massive.
<u> </u>	
Porosity:	ione
Beds:	planer, very think medium
Thickness:	5.75 cneky
Contact:	distinct
Foliation: -	planer
Joints:	one vearly vertical from top to fraction
Weathering:	peted dock goes surface at top and bottom
Surface:	Soll
Hardness:	moderate to Rank
Texture:	very fine to mean granular / crystalleine.
Grain Shape:	sousled to selesousided
Sorting:	wellsorted
Mineral components:	
Rock Classification:	Limesfone)

Sauget Area 1	
Rock Classification	Worksheet
Site	Diece #6, 16 inches, 117.03-118-36
Color:	lightgray
Rock Quality:	
	excellent, mauni
Porosity:	hove .
Beds:	planes, very Hock thick
Thickness:	NoneRes
Contact:	dubiet
Foliation:	glana
Joints:	Agregion to live 25 riches from top and
Weathering: stight	exhibited at separa better, dark quest without
Gurface:	solid
laraness:	moderate to have
exture:	me very fine to niew
irain Shape:	subscanded , angular organitation
orting:	well corted
ineral components:	calcile.
ock Classification:	linesfono

Sauget Area 1	
Rock Classification	workshoot
	Antronect
	light gray 118.36-118.51 (\$ poios, by)
Color: //	light gray
Dools Ownliber	
Rock Quality:	exallent, messing
M	
Porosity:	none
Beas:	
	puner, they there then
Thickness:	3 enches
Contact:	distinct
Foliation:	2 Venue
	planer
Joints:	Day 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Joints.	Horgantal to mercy housantal little freetures
Weathering:	
vveaulening.	surfaces top and bottomas petted rough
,	. Sui facel "
Surface:	
Surface:	Wold
Hardness:	
1 (0)(0)(0)5.	moderate to hand
Texture:	
i water.	very fine to new premeter
Grain Shape:	
Grani Grape,	subseanced
Sorting:	
JU: 11114.	well saited
Minoral comment	
Mineral components:	some celest
31-01	
Rock Classification:	limestone

Sauget Area 1	
	ه مر مؤسداسس.
Rock Classification w	orksneet
Site 4	uie 8, 11 miles 118.51-119. 43
Color: //	light orey
	and the second second
Rock Quality:	id +
i con addity.	excellent, massive.
Porosity:	irone
Beds:	slavar, very flech nesum
	planas, reng thank medium
This	
Thickness:	11 inches
Contact:	dutines
Foliation:	
rollation.	plana
,	
Joints:	bought wavy filled harlung time 450 bagle from fail attaction, dark group rough
M. alla a management	filler suiface
Weathering:	there to invalente along buttures.
Surface:	Sobil
Hardness:	
riaraness.	moderate to kand
Texture:	movery fere to muso granular
Grain Shape:	subsacrated, ergetale angules
	- Company of the Comp
Sorting:	1.011.0.101
·····ʊ·	well serted
Minanta	
Mineral components:	calcité present na sonailementals
Rock Classification:	finistano

Sauget Area 1	
Rock Classification v	vorksheet
Site of p	1ere #9, 1,9.43 - 120.56
Color: /	light gray
Rock Quality:	Excellent
Porosity:	none
Beds:	glaner, thick
Thickness:	13-5inche thirt
Contact:	distinct
Foliation: plan	vertical healer presence nearton
Joints:	
Weathering:	exhibited in fractures, and at togue bottom
Surface:	solut
Hardness:	maderate to Karel
Texture:	very fine to mucro gramulal, some systallystic
Grain Shape:	subsaunded, angular cognitalis
Sorting:	wellsexted
Mineral components:	Calente re creptals:
Rock Classification:	limentane

Sauget Area 1	
Rock Classification	worksheet
	worksheet
Site H.	icce: 10, 130, 56-121. 12
Color:	Lightonia
Rock Quality:	excllent, invessed
Porosity:	none
·	
Beds:	Olassica Without
	planer, song Hick medium
Thickness:	
, , , , , , , , , , , , , , , , , , ,	6.75cnedel
Contact:	
Contact.	distinct
Foliation:	planar
Joints:	wave doncental about the live
	A Vactoriera near laborem
Weathering:	experiented at topical total in the A
	Listerary at topical attom in circu felled
Surface:	sol I
Hardness:	product, to have
	franciae, A vale
Texture:	
	prespire to min previolet, some syntalizator
Grain Shape:	· · · · · · · · · · · · · · · · · · ·
orani oricac.	subscended to sub-angular
Sorting:	9
301 til 19.	well sorted
Airoral comment	
Mineral components:	At desseminated white specke (calite!)
Rock Classification:	(incorone)

Sauget Area 1	
Rock Classification	worksheet
0-1 1	
Set179, a	ece 11, 11.5 energe 121.12-121.76
Color: /	lightory
Rock Quality:	xcelled massive
Porosity:	none
Beds:	gland, ay their medium
Thickness:	U.5 inches
Contact:	distract
-oliation:	
ondion.	pirnal
Joints:	reache Unegontal nave fracture lines
Veathering:	exhibit has clay seam at top out balton
Surface:	role
lardness:	moderate to hard
exture:	verypine to miss granifer some apptilles
Grain Shape:	sounded to autrounded
orting:	well intell
lineral components:	with ciets.
ock Classification:	limitoni

Sauget Area 1	
Rock Classification	worksheet
1 ~	•
Color: '/	light gray 122-122.71 (porosity)
Rock Quality:	Lux
Porosity:	sone
Beds:	planer, monthick medium
Thickness:	8.51n
Contact:	distinct
Foliation:	plana
Joints:	Kongontal and rottical frantere lines
Weathering:	slight top a hettom
Surface:	solid .
Hardness:	moderate to Kurch
Texture:	very fine to incresembles
Grain Shape:	spended
Sorting:	well water
Mineral components:	some callere
Rock Classification:	limistoris

	Sauget Area 1	
Rock Classification v	worksheet	
Site of ac	ic 13 122.71-123.31 Lightfray	
Color: 1	lighthray	
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
Rock Quality:	lair	
Porosity:	none	
-		
Beds:	planer, melum	
Thickness:	7.25	
Contact:	dictinet	
Foliation:	please	
Joints:	Korizondat wave frectures	
187		
Weathering:	shight it top and atom	
Surface:		
Juliace.		
Haroness;		
riaraness,	moticate to Ward	
Texture:		
	resulting to microgranulas	
Grain Shape:	spended to subrounded	
	Market 40 surveyou	
Sorting:	willsorted	
3	2000 NOW!	
Mineral components:	a lendul the east	
	a few white spects	
Rock Classification:	horsestons	
The second secon	LIVIUM BY	

Sauget Area 1	
Rock Classification	1410 eli min ma
, took olassincation	worksneet
0.2.4	11/ 7:
ser Hill	217,3m, 1233-123,56
Color:	lght Slay 12331-123,56
Rock Quality:	Lan
Porosity:	to a 11 V m
	none
Beds:	
Deus.	plana , ving thick thin
Thickness:	3. Oinehel
Contact:	dutinet
Foliation:	
i onegon.	glanar
Joints:	wars fine lies at hother
Weathering:	slight at jop and bottom
	3 may mint
Surface:	apled
	<i>yau</i>
Hardness:	
Taluness.	ma serve to Karet
Texture:	sky roughinesto microganuter, flaky break
	stener.
Grain Shape:	so subspunded
•	
Sorting:	Live il inted
······ <del></del> ·	Line is is it
Aineral com	
Mineral components:	calub
Rock Classification:	lessectione.

Sauget Area 1	
Rock Classification	workshaat
	An United
Lato I are	eef5 12356-12383/f-
Color: /	lightened 1
Rock Quality:	Lacr'
Porosity:	
	Blone
Beds:	
0003.	planai ; Him
	1
Thickness:	
THICKHESS.	3. 25 mill, 1
.~	
Contact:	delinet
Foliation:	planes
Joints;	nons
Weathering:	shift out top
_	
Surface:	solid
	vac-s
Hardness:	Kend
, ,	Alss
Texture:	
rexture.	merogranular
Grain Shape:	sandy!
Sorting:	wellinted
Mineral components:	
Rock Classification:	limestory
	The state of the s

Sauget Area 1	
Rock Classification	worksheet
0 - 4 - 1	
Subset such	es/6, 123.53-124.46 light siny
Color: /	light could
	- Light yill
Rock Quality:	
accurry.	fur
Porosity:	none
Beds:	planar melum
Thickness:	7.5
Contact:	distinct
Foliation:	planar
, and the control of	planar
Joints:	
voints.	none westporthing clay felled fact battons
Weathering:	
vveathering.	at bottom
Surface:	solid
lardness:	hard
exture:	mero gramiar
Grain Shape:	sounded to subrounded. Become day too con
•	
iorting:	and soits
<del></del>	well gosted
fineral components:	
micrai components:	allite present
lock Classification:	Unestone

Sauget Area 1	
Rock Classification v	vorksheet
Sitist piece	217 124.46-124.63
Color:	lightgray
Rock Quality:	Lave
	/
¥	
Porosity:	jone
Beds:	planaa Him
Thickness:	Zinckes
Contact:	
Foliation:	elena.
	/
	<u> </u>
Joints:	every, foregental, and day jettletreatical
	Chartere 1
Weathering:	
vveautering.	along elect freehereat tog)
Surface:	solist
· · · · · · · · · · · · · · · · · · ·	<del>Ligarian</del>
Haraness:	producte to paril
	The same of the sa
Texture:	nuita chamine to
	niero granicar, to
Grain Shape:	essi recented to subspecial
	· · · · · · · · · · · · · · · · · · ·
Sorting:	wedsoutel
Mineral components:	day checto
•	
Rock Classification:	limitani

Sauget Area 1	
Rock Classification	workshoot
, took olassineation	AAO! V2HGG(
lition pu	cei eletion 18 120.63-125.30
Color: /	fighteras.
Rock Quality:	Lave
	/
Porosity:	none
Beds:	planar, thin to theat
Thickness:	.28" in total 11+ piece
	- Julian
Contact:	doctores
	asum
Foliation:	plonar
	Jen Marie Company
-	
Joints:	
	way practices
	1/ /
Veathering:	
, , , , , , , , , , , , , , , , , , ,	nan
Surface:	
Juneuc.	solid
laroness:	
idiuliess.	moderate to Karel
exture:	mind yunular
Grain Shape:	Manded
orting:	websorted
lineral components:	
ock Classification:	limentone:
	LUSTING VI SC

Sauget Area 1	
Rock Classification v	vorksheet
Site of gie	e. 19 125.30 h 125.45
Color:	lightmay
	agon: ag
Rock Quality:	
INOUN QUAINY.	cair
	1
Porosity:	non
Beds:	planer, Frest thin
	pure pur
Thickness:	
r mckness:	1.75 inches
Contact:	dutinet
Foliation:	Honer
	- Planter
Joints:	Realed vertilal fracture
	// '
Weathering:	nove observed
Surface:	solid
Ouridos.	Steel
Hardness:	moderate to haid
Texture:	miers ganules
Grain Shape:	searced
	Dunker
Sorting:	
Sorung:	irell unted
Mineral components:	~~~~
Rock Classification:	Line to de
· · · · · · · · · · · · · · · ·	Kimentoni

Sauget Area 1	
Rock Classification	worksheet
Site I pie	Lestory
Rock Quality:	
Noek Quanty.	Hus
Porosity:	in
Beds:	planer, then
Thickness:	3.75circles
Contact:	Misteriel
Foliation:	plane
Joints:	generally horizonth wavy felled prechases one fleshed fractually at 450 %;
Weathering:	and top, clasey
Surface:	30led
Hardness:	moderate to Hard
exture:	micro
Grain Shape:	
Sorting:	
Aineral components:	
lock Classification:	Unestone

Sauget Area 1	
Rock Classification	vorksheet
site I,	rice 21 125.76-125.91 light gray
Color: 7	light gray
}	
Rock Quality:	face
Porosity:	
Polosity.	noue
Beds:	plenas thick there
Thickness:	1,75
Contact:	
Contact.	distinct
Foliation:	2/1
	- fruitor
Joints:	none observal
•	
Weathering:	top + bottom slight
Surface:	
бипасе:	solid
Haraness:	
iai ai ta ag,	nod tokard
Fexture:	miero granulen
	The state of the s
Grain Shape:	
Sorting:	
Aineral components:	tu
Rock Classification:	Lynestone

Sauget Area 1	
Rock Classification	worksheet
1	
Littley 5	rieu 27 Hun 25 12591-126.32
Color:	lightsray
Rock Quality:	Lair
Porosity:	
rurusity.	1202
Beds:	thick planar, meleum
Thickness:	4. Genekei
Contact:	Sweet
Foliation:	planer.
Joints:	were time loves, deptilled,
Weathering:	exhibited using fractures.
Surface:	solis
dardness:	mex-stard
exture:	inato granousis-
rain Shape:	
orting:	
ineral components:	
ock Classification:	lemestoni

Sauget Area 1	
Rock Classification	workshoot
The state of the s	workgueer
late I o	uce 26 126.32-1 126.62
Color:	light succe
,	
Rock Quality:	
	fair
Porosity:	novi
Beds:	Planen, Ian
Thickness:	2/201
	3.625 in.
Contact:	Section
Foliation:	Kara
	./
	1'
Joints:	
Julius.	Rougantal fished him functioned, 2 healed
	restrict sactured
	1,
Weathering:	all shell at top & lotten
	Δ
Surface:	sold
	X1-47
Haraness:	
ndiulless.	most - Kand
Texture:	microspanukan
Grain Shape:	
,	
Sorting:	
- w. 111 135.	
1'	
Mineral components:	clarent experis
Rock Classification:	· le man dans de
,	- bleen was or v

Sauget Area 1	
Dauget Alea 1	
Rock Classification	worksheet
Stort .	ucee 27 124-62-126.79
100 L	lieb a / 121-12-1-01/1
Color:	hight gay
Rock Quality:	tair
Porosity:	none
Beds:	Clarks D.
	- process - process
Thickness:	2 inchi
Contact:	
Jonato.	destinia
Foliation:	
ronadon.	ylona
	4
Joints:	clay felled instruct at for + batter
Weathering:	top ahl fattern
Surface:	solul
	1 0 1
Hardness:	mot - haw
Texture:	mi jogranulai
Grain Shape:	
·	
Sorting:	
/ - · · · · · · · · · · · · · · · ·	
Mineral components:	
misiai components:	
Posts Class C	
Rock Classification:	Vim cufons

Sauget Area 1	·
Rock Classification v	vorksheet
life of our	e.28, 136.79-128.17 (2817, porosity)
Color: 7	Partition of the second
Rock Quality:	ian
	,
Porosity:	non
Beds:	Slavar theet
	/ *
Thickness:	
THICKHESS.	16.5 condies
Contact:	
Contact.	ti denet
Foliation:	
rollation:	planer.
	<i>y</i> .
Joints:	
Junita.	horezontal, clayer
Weathering:	at all of the state of the transfer of the
, , , , , , , , , , , , , , , , , , ,	exholight exhibited at top and tother
Surface:	ser. I
Hardness:	moreute to her
	my person 11 have
Texture:	11/642
Grain Shape:	
•	
Sorting;	
<b>.</b>	
Mineral components:	
Rock Classification:	Leves force
······································	LENCE TOLIS

Sauget Area 1	
Rock Classification	worksheet
Seti XY a	
Color: 'V	Lie 29 178.17-129.09 Light gray
Roc Quality:	Jac-
Porosity:	none
Beds:	glaner, medeum
Thickness:	11-0, nchis
Contact:	autinet
Foliation:	jelana
Joints:	dougantal wavy, find freetures, clay filled
Weathering:	slight at top & bottom
Surface:	soil
lardness:	1220
exture:	micro Ganara
Grain Shape:	
orting:	
lineral components:	some white specks
ock Classification:	linestons

125,135

Sauget Area 1	
Rock Classification	worksheet
101	
Site of sie	130, 139.09-130,46
Color: '/	light gray
Rock Quality:	della
·	
Porosity:	13020
,	
Beds:	stener - Auck
	france son france
Thickness:	
TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT	16.5 inches, 1
Contact:	
Contact:	district
Foliation:	plani li
Joints:	meny fine wavy exerctively horsen for
4	live bit trop hely five in bottom
Weathering:	shirt at too & battom battom dark sign
	and setted
Surface:	solid
Hardness:	mod to kul
Texture:	missi granciar
	January January
Grain Shape:	
- · · · · · · · · · · · · · · · · · · ·	
Sorting:	
ary.	
dinoral company	
Mineral components:	
Rock Classification:	limeitan;

Sauget Area 1	
Rock Classification	vorksheet
Sito I were	3/, 130.46 - 130.80
Color: /	light gray
Rock Quality:	Lair
Porosity:	hone
Beds:	planar, purplet melium
Thickness:	4.125
Contact:	destruit
Foliation:	plane
Joints:	find Prorgantal lines
Weathering:	desk group petted class at top
Surface:	Sot il
Hardness:	mod pilland
Texture:	mis ganular
Grain Shape:	
Sorting:	
Mineral components:	sysite infilling one XX fraction and as a 3/4 in
Rock Classification.	Genestens

Sauget Area 1	
Rock Classification v	vorksheet
024	ee 232. 130. 80 - 131.34 Growth Light say some looken gray specks +
Color:	light say some locket gray specks +
Rock Quality:	New .
-	
· ·	
Porosity:	None
Beds:	plunar, many / Write making.
Thickness:	6-Sinche
Contact:	Littlet
Foliation:	planes
Joints:	housantal fine lines
Weathering:	slightat lattom
Surface:	well
Hardness:	not to kay
Texture:	inisogranda
Grain Shape:	
Sorting:	
Mineral components:	
Rock Classification:	lemestans

Sauget Area 1	
Rock Classification w	vorksheet
0-0	
	(12) 33 13/34-13/51
Color:	light gran
Rock Quality:	- fair
Porosity:	None
Beds:	plana, then
Thickness:	2,0
Contact:	distinct
Foliation:	slana
	· .
Joints:	agregantal Spine brackery
Weathering:	slight at tro + Latton
Surface:	Total
Hardness:	mod - Kaul
Texture:	muso granulas
Grain Shape:	
Sorting:	
Mineral components:	some white outlines (facile (?)
Rock Classification:	limestone

Sauget Area 1	C, I, H
Rock Classification	worksheet Sith H
Piece #1-	8, 111-112.5 feet Selow Existing bade (SEG)
Color:	but prech surface in a grace to med light ray
Rock Quality: 3つ	1/0; pm, Ri-
Porosity:	inènt
Beds:	promo 2-7 cm thick (very thinto things
Thickness:	5morte_
Contact:	to distinct bretween sections
Foliation:	built some white specks to piecerup to Valory troumled to blocks pour be calculated they effective in HCI toffer
wanted	capital brocks + brockers
Joints: 5	within section is the little ( worky + che getter)
Weathering:	faceling
Surface:	Solid: Solutioned at assurement of anday
Hardness:	Bank
exture:	very fine (much less than I man) mon vocassing
Grain Shape: matry	too fine to tell, some inclusions care rounded to very uncular
orting:	Severally very well sorted
fineral components:	traces a black speed (hornohond), pyrite, possibly
lock Classification:	limestoic/; some shell fossils

Sauget Area 1	C. L H
Rock Classification	worksheet Site H
pièce #9,	Hes- 15.75 inches long, 112.5-1/3.81
Color:	chy-N7, lightony
	het -NT freeze ydy
Rock Quality:	mauri
Porosity:	- rone
Beds:	one had 15 tinchen thick, planar
Thickness:	15-75 inches
THOM:	13-17 yrahu
Contact:	
Contact:	ispper- broken rounded: lower with it was
Foliation:	plane
Joints:	Auch lower 3/4- Janineh Top; stria upper 5 miles
Weathering:	elight at with envir
Surface:	solil
Hardness:	April
Texture:	incregranular to crypt of a sense buch pints
Grain Shape:	: minded, & D. 2 mm or less
Sorting:	wellsorted
Mineral components	dessemated cale to? with timestone matrix
Rock Classification:	finestory.
	·

Sauget Area 1	STU H
Rock Classification w	orksheet' '
pièce 10	212" long 11381 -114.81 N7 tightyny
Color:	NT tight gray
	9 8 7
Rock Quality:	massie
Porosity:	juane_
ordany.	ment .
Beds:	And food sland, medium-thick
-	
•••	
Thickness:	212 inches
Contact:	district
	•
Foliation:	glann
	<u> </u>
Joints:	
the free on a figure .	wavystria startinget 7" below top and going to by them, sinkally lines but up to 2 mm, darter yay
	10 11 start Constant and Constant Const
Weathering:	sone, slight at top and battom
	, 3 V
Surface:	
ounace.	solid
	· · · · · · · · · · · · · · · · · · ·
Hardness:	Kard
Texture:	miero granular; some brachigot fissile
Grain Shape:	Sounded
Oram onape.	Mounted
Sorting:	weil sasted
Mineral components:	sexumented calate?, some b
Pock Classification	
Rock Classification:	finestone;

Sauget Area 1 .	St H
Rock Classification	worksheet
erice11; 36	meher; 114.81-117.81
Color:	
	100 15. 5" ned lighterey Nh: lightoray 15.5 to
Rock Quality:	man de la company de la compan
Porosity:	Mue
Beds:	Planer, Mad this to warme divis
	flower, that wary lines
	·
Thickness:	36 inchy
	·
Contact:	destinct
Foliation:	possionar + wave
	possionar + wory
Joints:	
	many strice resilivential at top; Koryanul
	bran I'ned strucker from top
Weathering:	for + fattom evelence.
Surface:	Solid
Hardness:	Harl
Texture:	1 MI ONA DIA LILI VOLA
	+ mengeannion
Grain Shape:	Doublet
	·
Sorting:	wellsorted
Mineral components:	New to Late 1 to 12 12 12 12 12 12 12 12 12 12 12 12 12
,	what the second second
Rock Classification:	Eneston ( breaks through aring et for mount
··· = ································	
į	grains at father queles

Sauget Area 1 Sauget Area 1 Rock Classification	H- worksheet	
pièce 12	10.75 inches; 2117.81 to 718.81	
Color:	light gray	
Rock Quality:	mariny	
Porosity:	none	
Beds:	one, florer, medium	
Thickness:	10.75 reles	,
Contact:	Settert	
Foliation:	fuite	
Joints:	Megular break	
Weathering:	puis slightat top and bottom	
Surface:	goli i	
Hardness:	ps Roud	
Texture:	macro clanular, eccessional hracheogra shell	
Grain Shape:	hounder	
Sorting:	wellgorted	
Mineral components:	approximately 1/2 inch wife trendat hotom aine bull backsnicke: 3 mm wile interreg horistanda	475 Min. 1
Rock Classification:	Lines for i	i7.5 from tof

Sauget Area 1	
Rock Classification	ite H
INOCK Classification	worksneet
1 - II-	)
Rice#13	18.81 to 119.10
Color:	
7	Light ray IV
Rock Quality:	Masive
Danniku	
Porosity:	Marie
Beds:	planer, think way think them
	party that they then
	*
Thickness:	235mily 3.25m
Contact:	
Comact.	distinct.
Foliation:	Africanory lines
	of aware the second
	· j · · · · · · · · · · · · · · · · · ·
Joints:	slana
	V
Weathering:	
rroantenny.	slight
Surface:	Splil
	3,000
-lardness:	Hard
exture:	
	rountel
Grain Shape:	rounded
Sorting:	well contest
g.	med cores
lineral components:	whi
•	
Ock Classification	
Rock Classification:	lemestone.

Sauget Area 1	4 11
crise # 10	1; 14.5/nelle long 119,10 to per, 120.31
Color:	light say, N 6;
Rock Quality:	massue
Porosity:	rone
Beds:	planse, rong thick
Thickness:	14:5 inches
Contact:	destinet
Foliation:	wary lines plan top and at bottom; brass
Joints:	planar way, chay felled
Weathering:	sanslight at top thatben
Surface:	solid
Hardness:	Hund
Texture:	mus) znala
Grain Shape:	sunded
Sorting:	wellsorted
Mineral components:	custale one soch + Strake
Rock Classification:	Cerentone

Sauget Area 1	
Rock Classification w	rorksheet
Sils H	Dice 15: 3.75 inches; 120.31-120.62
Color:	tightery, N.7
Rock Quality:	masure
Porosity:	none
Beds:	glans, was that your
71.	
Thickness:	3.75 mily
Contact:	
Contact.	dutinet
Foliation:	
	wary horgantal to seerly vertical
Joints:	1.0 1/ 6.4
	tog & battom
Weathering:	at top + bottom
J	
Surface:	Solid
Hardness:	Kend
Texture:	necro granular.
	7
Grain Shape:	sounded .
Sorting:	wellsate
3.6:1	
Mineral components:	nejor selvice?
Rock Classification:	limestone

Sauget Area 1	
Rock Classification	worksheet
0	
Site H o	100 H 16, 5.675 in, 120.67-121.10
Color:	Latt gray
,	
Rock Quality:	indident
Porosity:	
Pulusity.	is some
Beds:	planary thin
Thickness:	2-3meles
Contact:	elistines
	fliddingt
<b></b>	
Foliation:	wavy plane
	^
Joints:	wave
	<u> </u>
Weathering:	at ton + hollow
<b>J</b>	as y ranon
Surface:	
Juliace.	poled
,	
Hardness:	inducte to have
Texture:	Recognance
Grain Shape:	sounded to subsounded
17 T.	- Journal To autorounce
Sorting:	
ourmig.	wellaster
Mineral components:	calcie ? as sounded 12 notates : som
	<b>/</b> *
Rock Classification:	Vimestane.
	·

ſ <del>-</del>	
Sauget Area 1	
Rock Classification	worksheet
0=411	
Dite the ou	light gray 121.10 to 121.93
Color: 7	helt nous
Rock Quality:	marien
Porosity:	3 _ 0
	bone
Beds:	
De03.	planus, sey thatis medium
Thickness:	
I NICKNESS.	10 makes
Contact:	distinct
Foliation:	horgantal swary
	The state of the s
	_
Joints:	
	flener
Weathering:	
vveatnering.	at top 4 bottom
Surface:	solid
Hardness:	moderate to have
Texture:	million with A
	- marganer
Grain Shape:	sundert
orani onapo,	Selender
?	
Sorting:	wellsowed
Mineral components:	estait as rounded Vi notules
	· ·
Rock Classification:	V
	Millory

6/5

Sauget Area 1	Warkshoot SiteH
Rock Classification	worksheet 2004.
SilH. piec	e18. 13.5-13.13
Color:	light nay N7
Rock Quality:	excellent, musery
Porosity:	none
Beds:	placer, row that melium
Thickness:	10 menes
THICKINGS.	10 well
Contact:	destinis
	ascul
Foliation:	plexer
Joints:	vertical to inclined bussifiled willey
	Cailwey parts of they
Weathering:	tand leggy top ind bottom are elightly putted
	and clayer 1
n	
Surface:	Solut
Hardness:	De l
naruness.	24.L
Texture:	and in the last the l
	John brackward their inarcians
Grain Shape:	some practional (Asul impressions)
	- Lance
Sorting:	wellsorted
<del>-</del>	1
Mineral components:	The deer of
Rock Classification:	Linestonie

Sauget Area 1	
Rock Classification w	orksheet
0-0	723/3-12442 10:15-5-31 123/3-12442
Sitt H. w	eses 9: 15.5 mikes 13313 - 134/12
Color: /	Liebt saci N7
Rock Quality:	Dea exallent marient
Porosity:	none
Beds:	planar, was their
Thickness:	15.5 cricker
Contact:	distinct.
	, w4
Foliation:	planul find throughout tentil clay
. (	lilled !!
	<b>7</b>
Joints:	Line wasre Mushelled Koreantal + and
	miliablites Hubbites recasionally
Weathering:	slight to fresh; top and button exhibit netted
	clayer surface
Surface:	50lid
Hardness:	moderate to hard
<b></b>	
Texture:	microgranular 261mm
Grain Shape:	sounded to subsourled
<u> </u>	
Sorting:	wellsorted
1. f 1	
wineral components:	none additioned observed
	<del></del>
Rock Classification:	4 mes tone

Sauget Area 1	
Rock Classification v	worksheet
0 .	17442-1270
Site H; siece	20, 10 inches 134.42-135.05
Color: /	light gray NT
Rock Quality:	exillent, musery
Porosity:	none.
Beds:	planar think natur
	/
Thickness:	Dineky
Contact:	arriet
Foliation:	planar
Joints:	prove felled bester at top
Weathering:	textilized at top + buttom; petaling filled
	pretures "
Surface:	
Surrace;	solis
Hardness;	
i idi unigaa,	moderates tollers
Texture:	
TOXISTO.	very fine to mesogranatures
Grain Shape:	rended
and a special section for section 1	Alleria
Sorting:	well dan text
रूप प्रशासन्त । जन्म	well sortes
Mineral components:	1.00L 1. 1.0 L 2.0 7L7
compared and commentations	white a few white estate?
Rock Classification:	Linestone
TOUR CRESSINGUIDIT.	unesteno

Sauget Area 1	
Rock Classification	n worksheet
	125.05-127.51
Sife H, pe	ee 21, 29.5 inches; 135 05-13751
Color: ' /	Kehlory N.7
Rock Quality:	excellent, marrie
Porosity:	
or out,	none suigen rock, settly in fringesetures
Beds:	
Deus.	planal, their
Thickness:	29. Scriber
Contact:	distinct
Foliation:	planar
	yeara.
Joints:	
oomits.	wavy lines in mittle section and at loverend
	possibly clay felted purious, severally a much darket
Monthaga	sing on pulleful (suffeel (N3)
Weathering:	only in particle, too and hottom
Surface:	- Adled
Hardness:	moderate to hand
	<del></del>
Fexture:	again to the second of the sec
	very fine to muso granular
Grain Shape:	rounded.
and the same of th	similar,
Sorting:	
orany.	and Cleanted
/lineral components	pysite on one practure line
lock Classification:	limestano)

Sauget Area 1	
Rock Classification	worksheet 1780G
	12/5/- 1201/1
Sitt H wie	e 22.17.75 miker 137.51 135,99 lightonay
Color: '/	lightorau
Rock Quality: p	excellent misure
Porosity:	none more timbers
,	none except in practace
Beds:	plinaster shik
	perna ring incia
Thickness:	17.75
111100111100000	
Contact:	
Contact.	detirit
ralara,	
Foliation:	planar
	/
Joints:	situal racture lines, cher littled service
	in facture at 33 riches from potons. Weset
and	settled in middle insetule
Weathering:	some within along lower buctures - show t
Surface:	sich d
	<i>⋠</i>
Hardness:	moderates to bank
Texture:	on a melo la maria la maria de la maria della maria de
	granular very time to rueso
Grain Shape:	in the day of the state of the
	sounded to subsuended; some XL's angular
Sorting:	well sorted
<del> </del>	well street
Mineral components	
Militeral combottents	calcute, pyrite in one preter
D==1-01===i6==i	
Rock Classification:	limetans

Sauget Area 1	
Rock Classification	worksheet .
	128.99 - 129.91
Setatt 1.5	e 23: 11 meker 138.97 to 139.91
	e 23: 11 meker, 138.97 to 139.91
Color: '/	light gras NT
Rock Quality:	excellent, miling
Porosity:	nen
0,2011).	
Beds:	slener, seethick-nelum
Thickness:	1 lineke 1
Contact:	
oomaot.	declinet
<u></u>	
Foliation:	plana
Joints:	in all to the little to the second
	waves from fellet pactures a totom and sutures
	Ranging cray felter
Weathering:	
TTOGGICIRIG.	along pactace lines
Surface:	solid
Hardness:	How moderate toller
	TUREST TUREST
exture:	
CALLIC,	granular; very pero to micro
Srain Shape:	subsounded to something subangular
orting:	wellsorted
lineral components:	1.1. 6
cidi components:	Calcut
ock Classification:	limistane
<u> </u>	

Sauget Area 1	
Rock Classification	worksheet
1	$-\alpha + \alpha +$
Sitt H pr	129.91-130.64 ev 24 8.75 inches; 139.91-142.64 Light suy
Color: /	light day
Rock Quality:	exallent musing
Porosity:	neral
	· · · · · · · · · · · · · · · · · · ·
Beds:	planar fing the one thin hed at forton
Thickness:	<u>\$.75</u>
Contact:	distinct
Foliation:	plann
Joints:	clay filled wavy planar fracture lines.
	John Marine Property and the second
	· ·
Weathering:	En exhibitedin pretuis a
İ	the continues of the same of t
Surface:	Bolid
Hardness:	moderate to Rand
Texture:	men very fineto mieso asserbas
	mer very fureto miero granulas
Grain Shape:	sounded to subsampled
¢.	Sounder II sumpuner
Sorting:	wellsorted
Ü	The will be the second of the
Mineral components:	D
and control or according and control or a	
Rock Classification:	Amestone
(OUN ORGANICATION,	ginistans

Sauget Area 1	
Rock Classification v	vorksheet / .z/ .c/
<b> </b>	130.64 - 131.04
Site H-	uge 25 4.75 miher, 440 pt - 14 tot
Color: /	light gray N7
Rock Quality:	mession
Porosity:	Ane
Beds:	
	Planar return
	1318 Mar There
Thickness:	
rinonicas,	4. 15 meher clay/skale layer at bettom
Contact:	distinct
Foliation:	planar.
	Å
Joints:	wavy fine pretur lines
	A
Weathering:	exhibited in clay filled practure
	The property of the second sec
	1
Surface:	solut
Hardness:	moderate to hard
· · · · · · · · · · · · · · · · · · ·	MARIAN TO MUIL
Texture:	
CONGIO,	very fine to muse grenuler,
Grain Shape:	
зташ эпаре.	subspice lel
Sorting:	well sorted
	-
Mineral components:	Calcib
Rock Classification:	amestone

Sauget Area 1	
Rock Glassification	131.04-131.81
Dices 2642	7.10 meles 141.04 - 141.82 MMW
Color:	helitory
Rock Quality:	excellent prayetre.
Porosity:	none
Beds:	
	plance, bery thoch medium
Thickness:	Durcher
	1000000
Contact:	Nitimet
Foliation:	planer:
	June -
	·
Joints:	nou
Weathering:	exhibited at topin day filled prestrict
Surface:	solist
Hardness:	moderate toffeed
Texture:	
rexture.	, aling ganulas
Grain Shape:	sounded
Jiaili Silape.	sounded
Sorting:	wellsarted
outing:	well sarted
Mineral components:	
mileral components:	
Rock Classification:	
TOUR CIGOSHILARUIT.	lincotone

Sauget Area 1	
Rock Classification	tional about
NOUN Classification	worksneet
its I 111	-113 feet ke s , 5 proie
Color:	relighed gray then high through
	the again pur
Rock Quality:	
intock Quality.	por
Porosity:	40.40
,	some
D-4	
Beds:	1555 3-15 west glaver thing there the
Thickness:	7.5 to 3.75 miles
	12 D DIT MIKIN
Contact:	distinit
Foliation:	
is undergit,	plana
•	
Joints:	wary fine lines nearly hargental
	way fill und many margental
Weathering:	exhibited along frectus line
Surface:	Soliet
	Dollar .
Hardness:	most to Karel
Texture:	
CASGIC.	very fine to mucho demin
	very fine to micro gramin
Grain Shape:	reunled to subrounded
Sorting:	well-certed
·······················	recident
Mineral components:	white specke
₹ock Classification:	
TOTA CIESSIFICATION.	finatore

Sauget Area 1	
Rock Classification	n workshoot
. took Olassincatio	ii worksiteet
litt I	116-118; 10 puzze.
Calor:	holitail
Rock Quality:	1111
	The state of the s
Porosity:	
	120-14
Beds:	
	places, very thin to medicine
Thickness:	
rindariess.	0.125 chickes to 4 wiches
Contact:	dulturt
Foliation:	elana
Joints:	Gorgantus
Weathering:	none observable
Surface:	solid
Hardness:	modera to to hand
	mana a man
Fexture:	
. watu,	
Grain Shape:	
oram onape.	very fine to mieso granular
	<u> </u>
Sorting:	wellsuited
Aineral components	white pecks throughout
Rock Classification:	

Sauget Area 1	8
Rock Classification worksheet	4工
118-1265, Sand to 1	20.5; unkegung rock type 170.5-126.
molare 5	ample 120,5 to 176, mad thoug ducting
Rock Quality:	House Cours
Porosity:	
Forosity.	
Beds:	
the death of the first and the	
Thickness:	
***************************************	
Contact:	
Contact.	
Foliation:	
Joints:	
12/2	
Weathering:	
Surface:	
**************************************	
Hardness:	
Texture:	
Grain Shape:	
	•
Sorting:	
Mineral components:	
Rock Classification:	
***************************************	
**************************************	

Sauget Area 1	
Rock Classification v	workshoot
TOCK Classification v	MOLKSHEEL
Sit I vice	63-14hough 12-5 124.5-127.02
Color:	bestoling gay
	ogy o was gray
Rock Quality:	excellent, manine
Porosity:	
ir orosity.	now
Beds:	placed, very then to the
Thickness:	
· · · · · · · · · · · · · · · · · · ·	0.25 to 2 credes
Contact:	Chatter F
Foliation:	
rollation,	place
	*
Joints:	Marine Marine James II II
	wary, vaile horizontal
Weathering:	shight at town and existen of preser
	Shift et top and bettom of ciece
Surface:	soul
	-Stoller
Hardness:	most to trank
Texture:	
- m-16463 W/4	sery fine to muso granular
Grain Shape:	sounded to subscultural
Sorting:	wellsonted
· ····· · <b>.</b> ·	weary ou
N. C.	
ivilneral components:	Same white specks and notices
Rock Classification:	limes force
	Lumi Liffer L

Sauget Area 1	
Rock Classification w	rorksheet
10 0	
SUZ-	uce v 12-6 /27, 02-121.54
Color:	light gray
Rock Quality:	excellent
Nock Quality.	sxillent
Porosity:	hone
Beds:	Dener, refreem
Thickness:	6.25 may, nedum
Contact:	
Comaci.	Meterel
Foliation:	Plane
Joints:	wary, larguntal clay filler
Weathering:	getted surpress at top and button
01	
Surface:	solid
Cariaco,	3004
Hardness:	moderate to have
Texture:	
rexture.	Tresifence to misso granula, plaky breakage
Grain Shape:	And subscended to divariation
Sorting:	wellsarted
Mineral components:	
c.a. components.	Accemental white specks, colored
Rock Classification:	linestone

Sauget Area 1	01EU-12762 (1)
Rock Classification	worksheet 137.59-137.92 pv
Sto I p	127.501-128.50
Color: /	Lest gray 127,501-128,54
Rock Quality:	2x cellent
Porosity:	none
Beds:	plener, their
Thickness:	12 cneker
Contact:	Listeriet
Foliation:	plena
Joints:	horsontal wave line lines + solut
Weathering:	such petted surfaces at top + tratomic)
Surface:	solid
Hardness:	And
exture:	very fine to mesoglacular
Grain Shape:	subsambled to angular
Sorting: .	well satis
Mineral components:	Coleita, a few white speck!
lock Classification:	<u>Unestani</u>

Sauget Area 1	
Rock Classification	worksheet
Site I	Decie 12-8 128.54 - 129.35
Color:	hold many
Rock Quality:	excellent
Porosity:	nane
Beds:	plener medicin
Thickness:	9.75inches
Contact:	distinct
Foliation:	planac
Joints:	very fine lines, Aorigontal to sul-horizonital
Weathering:	petted surface attop, dull claying at hatton
Surface:	solich
lardness:	moderate to hand
exture:	very finite in magazinela
Grain Shape:	subrounded to subargular
orting:	wellvarted
lineral components:	dessimilit whitespecks
ock Classification:	Pemeitani

Sauget Area 1	
Rock Classification	worksheet
^ (	workdot
Sile I, is	2-9; 129, 35-132.04 light gray
Color:	light crain
Rock Quality:	excellent
Porosity:	
rolusity.	none
Beds:	flance, very thick
Thickness:	32.25 miles
Contact:	duand
Foliation:	plan
Joints:	planes, sulue like, Borgontal, Three
Weathering:	slight at top & pottom
Surface:	solist
Hardness:	moderate to hark.
Texture:	renfin to missognation
Grain Shape:	subscended to subsequen
Sorting:	wellsouted
Mineral components:	dessiminated white specks
Rock Classification:	femeitene

Sauget Area 1	
Rock Classification v	vorksheet
SiGI 12	Picel 10+11 15/32.04-132.35
Color:	1 ght gray
Rock Quality:	exceller
Nock Quality.	excellent
Porosity:	nonl
Beds:	planes very their to their
Thickness:	
inickness:	0.75 Dans 3 credet
Contact:	- declinet
Foliation:	Plane
	• • • • • • • • • • • • • • • • • • • •
Joints:	me in clonder of viece 11, wany filled
Weathering:	petted surface an bottom of since 11
Ŭ	fire my regard process
Surface:	50lis
Hardness:	moderate to Paral
Texture:	
	sexpling to mucro
Grain Shape:	subspunied to regular
	-
Sorting:	wellsorted
Mineral components:	
	usy, colut
Rock Classification:	linestons.
	L'UNINTEPU'

Sauget Area 1	
Rock Classification	worksneet
C 3 -	_
LXIT I p.	ec 17, 132,35- 132,77
Color:	
,	lifetina.
Rock Quality:	ecelleni
Porosity:	
7	None
Beds:	plane, pelium
Thickness:	Secretary and the second secon
	Genelia reduin
Contact:	Westingt
Foliation:	A # .
r Ghatiori,	stana
	<i>y</i>
Joints:	Lower fine lines, medgly, N5 brust and
	to All hetter
Weathering: /91ed	
vicumening.	
	succes 1
Surface:	521
lardness:	
raidiless.	more to Hand dust grow bouch slightly
	more soft than medile
Texture:	very fine TV mees oganules
	The state of the s
Grain Shape:	
	surrended (derk hands), subscended to
<u> </u>	Succession
Sorting:	wellent
Mineral components:	(4/2)
,	- Tuiz
Pools Clarate	
Rock Classification:	Comen Freix

Sauget Area 1	
Rock Classification	Worksheet
0 0	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
XIT	7.112777-13 122 123 123
Color:	2016-13-13,132,77-133,87
/	light say
Pook Ourth	
Rock Quality:	excellent
Porosity:	none
Beds:	sienar, thick
Thickness:	Brades, thick
Contact:	district
Foliation;	planas
Joints:	stas wavy fine filled lines?
	James Hall Penels
Neathering:	slight at in 4 bettom
Surface:	said
lardness:	moreute to Kend
exture:	Deurha De massel
	reupen to mangramlar
irain Shape:	subsacrated to subangular-
, 	purpose of surangular
orting:	reliented
•	- Deusin W
lineral components:	
- veriponenta.	white speeks
ock Classification:	
Organication:	Minicitanie

Sauget Area 1	
Rock Classification	workshoot
1	WOLKSHEE!
Silf I, p	Light gai
Color:	light of all
	$\overline{\mathcal{F}}$
Rock Quality:	excellent
Porosity:	- lione-
Beds:	plana, their
Thickness:	
mickness:	1.25,
<u> </u>	
Contact:	distint
Foliation:	elina
	į.
Joints:	wary, filled few horizontaj finie
Weathering:	slight at top + bottom ande
Surface:	solist
Hardness:	mod tikend
Texture:	muss
Grain Shape:	
Sorting:	
Mineral components:	
Rock Classification:	James toni

Sauget Area 1	
Rock Classification	Worksheet
Sit; I	1.2-15 13.2.97-133,99 light gray
Color:	light gray
Rock Quality:	
TOOK Quanty.	excellent,
Porosity:	none-
Beds:	grener thick
Thickness:	12.25 in ker
Contact:	distinct
Foliation:	
Chatton,	plana
Joints:	Other harmonia and the second
	grant plew, Gargantal wavy fine lines
Veathering:	slight at topand bottom extent surprise
	sugar as topans cottom peter surface
Surface:	soled, some lake you shapes possily forsile.
lardness:	most to Kend
	- Contraction of the contraction
exture:	Auch yoular
rain Shape:	rounicet
orting:	mell cortil
ineral components:	
ock Classification:	Vinestoni
- Comment of all a Section 1997	<u> </u>

Sauget Area 1	
Rock Classification	worksheet
11	
Dili.T	12-16, 133.99 - 124 -9
Color:	12-16, 133.99 - 134 59 agent gray
Rock Quality:	excellent
	LA CEURIC!
Porosity:	Sole 1
Beds:	planer, netuin
Thickness:	7.25, medium
Contact:	Chatenet
	- I Rauni
Foliation:	flanar
Joints:	adding want 1 the Plane & the
	as fine waver felled horgental Penies
Veathering:	
· · · · · · · · · · · · · · · · · · ·	slight as suled surfaces on top & button
iurface:	Solid
lardness:	moderate to have
exture:	mero ganular
rain Shape:	meso granulas.
orting:	wellsontel
ineral components:	
ock Classification:	(incitoni)

Sauget Area 1		17/159-135-11 246-15-1
Rock Classification	worksheet	134.59-135.01 porusity
Site I,	17-17-18	134.59-13542
Color:	light nay	
Rock Quality:	excellent	
Porosity:	*	
l olosity.	none	
Beds:	planse, melu	Lun
Thickness:	10.0	
Contact:	disting	
Foliation:	glenar	
Joints:	nons showed	
Weathering:	sight, pitted for	prinface
Surface:	solut	
Hardness:	most to have	
Texture:	mesogamian	
Grain Shape:	sounded	
Sorting:	well soled	
Mineral components	Cally	
Rock Classification:	Cinestoni	

Sauget Area 1	
Rock Classification	nn worksheet
	m warksheet
Six I	136,5-137.44
Color:	lighterry excellent
Rock Quality:	200-04/4-3
	VECUCION.
Porosity:	you
Beds:	plener, me lium
Thickness:	11.25
Contact:	
oomact.	destinit
Foliation:	pienel.
loints:	
	the non
Veathering:	Shight top 4 harton
Surface:	Soled
lardness:	more to Keny
	mod tokken
exture:	miero granulas
rain Shape:	
`	suirounded to and angeles
orting:	200 vertes
ineral components	i Calla
ock Classification:	lime of 2.21

Sauget Area 1	
Rock Classification v	vorksheet
Site I LE	0-30 137.44 - 137.61
Color:	lightoni
Rock Quality:	exiclent.
Porosity:	noni
Beds:	plania
T-marine	
Thickness:	2.125
Contact:	distant
Foliation:	fleun
3	
Joints:	fair wave there were felled lines
Manthana	
Weathering:	Period surface at top sonorth stryly (studie)
	I lesse at lattone
Surface:	
Surrace.	Solid
Hardness:	mod to ke w
idiumuu.	mod to fre w
Texture:	
Theresises up.	mich Manulas
Grain Shape:	
ومسطمة المساور وورسي والمساور	subscumber to sed-argula:
Sorting:	- Mrs. O
oog.	VIII. U
Mineral components:	Gills
tang control or mitted mittanistmen	9,003
Rock Classification:	ami stant
TOOK GROOMINGER,	amiistry

Sauget Area 1	
Rock Classificatio	n worksheet 137.61-137.84 (paweity)
Qily T ;	3-21 137.61-13805
Color:	-dight stay
Rock Quality:	exillent
Porosity:	120m
Beds:	plenar
Thickness:	5.3 5
Contact:	destinet
Foliation:	please
Joints:	fatter to
Weathering:	sight at top & bottom
Surface:	5Hill
Hardness:	not to hard
exture:	mici) gamen
Grain Shape:	subscurded to subsugative
Sorting:	me d'
Aineral components	: lalez
Rock Classification:	Licustoni

Sauget Area 1	
Rock Classification v	vorksheet
Site I is	2-78 138.05-139.47
Color:	hight gray
Rock Quality:	2x. Elent
Porosity:	11.on!
Beds:	glana, Hirt
Thickness:	D.O, Freek
Contact:	Chiteried
Foliation:	the Hom 7. Sinchia
Jaints:	Dergartal to suphongent if fine moun
Weathering:	surface surfaces on Lop and bottom
Surface:	Soled top 9.5 maker, pott small pite Faller
Hardness:	movements to hard
Texture:	missi statista
Grain Shape:	
Sorting:	NEWSCH
Mineral components:	akitaystale in potom 1.5 inches, do por
Rock Classification:	Phonestoni

Sauget Area 1	
Rock Classification	Named and the second
TOCK Classification	worksneet
<b>-</b> /-	
-XUI V	UN 12-23 19739,47-141,77-
Color:	heldson
	eght swer
5	
Rock Quality:	Exectle, et
n.l	
Porosity:	
	juste
Beds:	Planer, friek
Thickness:	22:4
	37 ineles
Contact:	chilinet
Foliation:	
i OliatiOff.	plans
Joints:	to receive except at patterns
	to great in the contract
Weathering:	
vveamenng.	thek petted surjected button
e e	
Surface: serruit	total prited in 10p 3.5 coules
2-01/04/4/0	James in 17 7. ) inchil
i	
lardness:	moderate & Hard
exture:	sulas maneia
	January Constitution of the Constitution of th
Brain Shape:	
oram onape.	
Sorting:	
lineral components:	
	a bear hop shape in top Sinike Red apparent
	persett in it
lock Classification:	1 Kenzyow

Sauget Area 1	
Rock Classification	suprison and
, Took Gladoline alloli	MOLKSHEEL
StIT	17-24-26 141-0- 142.03
Color:	light cray
Rock Quality:	Calle I
Porosity:	11000
Beds:	plane
Thickness:	3.75-rules total Pack =1.35 creby
Contact:	dutinet.
Foliation:	gener -
Joints:	multitude? him wary subtrangental him
Weathering:	Mone fracture vines sognitudes peciel
Surface:	salil
Hardness:	1127/ to paral
Texture:	mito
Grain Shape:	
Sorting:	
Mineral components:	
Rock Classification:	(uneithry

Sauget Area 1	
Rock Classification	worksheet
.) ,	worksheet 142.03 - 144.2/
Sditi	3-27 141.77=143.90
Color:	dight sing
Rock Quality:	Lyce llent
·.	
Porosity:	none
Beds:	intop 33, white Weaker Iso How 13
Thickness:	26.175in.
Contact:	Meximit
Foliation:	plune
Joints:	al de wary fine Pullarizant find lines
Veathering:	Slight at topd kattom ends
Surface:	- social
lardness:	1225 21 to Mary
exture:	Augrania in
rain Shape:	mani-1
orting:	mell
ineral components:	CA(63
ock Classification:	llineatons

Sauget Area 1	
Rock Classification w	rorksheet
	1111-1 - 1447 6
Set II in	2-25, 743, 91) -144, 25
Color:	Listoner
Rock Quality:	ENZERALT
Porosity:	none
Beds:	planer, mekeen.
Thickness:	4 25 indus
Contact:	<del></del>
Comaci.	- Wistingt
Foliation:	
onbuon.	Haire
•	<u> </u>
Joints:	
	as porary live at top
Weathering:	an potted surfaces on top of bottom
Surface:	solil
Hardness:	
riaruness.	mod-hard
Texture:	Della della de
	The symmetry
Grain Shape:	nussgunda Novalul
·	
Sorting:	ned serted
Mineral components:	
Rock Classification:	linestan

Sauget Area 1	
Rock Classification	worksheet
	144.56 - 14527
SitiI	id-29 144.56 - 145.27
Color:	aghteray
Rock Quality:	excellent
1.	
Porosity:	
orosity.	Done
Beas:	all a second
	planar, melian
Thickness:	5,5
Contact:	
Contact.	distinct
Foliation:	
	planer
Joints:	as fine horegonal to subhoresontal lines
	as fine horgantal to subhorgantal lines
Weathering:	slight as getter day surfreesat top and
	potom
Surface:	Solid
	- AULA
	^
Hardness:	not to band
Texture:	miero granular
Grain Shape:	
orani oriape.	
Sorting:	
dineral components:	
Rock Classification:	limestand

Sauget Area 1	
Rock Classification v	worksheet
	145.77 - 145.70
Sete I. i	2-30 144.96 14539
Color:	belitones
Rock Quality:	exichent
Porosity:	
r orosky.	none
Beds:	glasas, medicin
Thickness:	5,125
Contact:	Nistret
Foliation:	
	iperate -
-	<del> </del>
Joints:	all 1:00 11 + +0 11 + 21 = 11 + +1
w w	Clayfilled at top black string + pettel on.
	wash.
Weathering:	
vveautering.	pitted black bottom
	/
Surface:	Toled: pitted felled pacture in meddle
Hardness:	instarate to hard
Texture:	nvero granula.
Grain Shape:	rounded
	*
Sorting:	well
Mineral components;	
	posts true perite
Post Classification	, , , , , , , , , , , , , , , , , , , ,
Rock Classification:	limetory

Sauget Area 1	
Rock Classification	Worksheet
() A	145,70 - 146,91
Sile I is	1-3/ -145-39 = +41-1/2"
Color:	1.01
	- Mar Siry
Rock Quality:	excellent
	SAULUS F
Porosity:	10.
	none
Beds:	planer, thick
	Jewsey Truck
Thickness:	14.50
Contact:	destinct
Foliation:	ala u u A
Joints:	one suborcental trabite
	- sypolity in mille
Veathering:	pittel surpre on too Cheore
	1 page 1
Surface:	solid
lardness:	moderate to land
exture:	very fine to micrograpula
rain Shape:	Sander
orting:	well
	<u> </u>
ineral components:	some freed white blotcher
ock Classification:	kmesten



GSI Job No. G-2876 Issued: August 28, 2006

### **BEDROCK TRANSPORT EVALUATION**

Sauget Area 1, Sauget and Cahokia, Illinois

# ATTACHMENT J-3 - THIN SECTION ANALYSIS REPORTS

Reports of Thin Section Analysis from American Petrographic Services, Inc. (Source: pages 147A-1 to 147A-21 from Volume 2 of Field Sampling Report, O'Brien & Gere, September 2000)



July 13, 2000

O'Brien & Gere Engineers, Inc. 12250 Weber Hill Road St. Louis, MO 63127

Attn: William Wright

Subj.: Solutia, Inc.

Sauget Area 1

APS Job No. 10-01078

Dear Mr. Wright:

This letter presents the results of our observations made on 29 rock core samples. The scope of our work was limited to visually documenting the relative porosity of the rock samples or selected areas within the rock samples by thin section analysis. The samples were submitted by Mr. William Wright of O'Brien & Gere, Inc. on June 5, 2000. Our work was authorized at that time.

#### **Observations**

Sample	Lithology	Porosity	Comments	
G, 112.2 -112.46	dolomitic limestone, biosparite	moderate	dolomitized throughout	
G, 114.74-115.07	limestone, pel-biosparite	low	well cemented	
G. 116.11-116.53	limestone, oo-pel-biosparite	low	well cemented	
G, 118.36-118.51	limestone, oo-pel-biosparite	high	many stylolites	
G, 120.56-120.89	limestone, pel-biosparite	low	few scattered interfragment pores	
G, 122.41-122.71	limestone, biomicrite	med-low	dense, 2 thin stylolites	
G, 124.17-124.46	limestone, oo-pel-biosparite	low	dense	
G, 126.79-127.13	limestone, oo-pel-biosparite	low	dense	
G, 128.42-128.73	limestone, oo-pel-biosparite	high	concentrations of subparallel stylolites	
G, 130.80-131.10	dolomitic limestone, biosparite moderate dolomitized		dolomitized zones throughout	

Sample	Lithology	Porosity	Comments	
H, 111.83-112.19	limestone, biosparite	moderate	some sutured stylolites	
H, 113.46-113.81	limestone, biosparite	moderate	some crude stylolites	
Н, 115.76-116.03	dolomitic limestone,	high	dolomitized throughout	
H, 118.04-118.46	calcitic dolostone, biosparite	high	dolomitized throughout	
Н, 119.87-120.29	limestone, oo-pel-biosparite	low	dense sparite cement	
Н, 121.43-121.63	limestone, biosparite	moderate	some stylolite swarms	
H, 122.5- 122.79	limestone, biosparite	mod-low	one stylolite swarm	
H, 125.30-125.59	limestone, oo-pel-biosparite	mod-low	a few pores in drusy sparry cavities	
H, 128.99-129.39	limestone, pel-biosparite	moderate	some crude stylolites	
H, 131.04-131.43	limestone, biomicrite	low	dense micrite matrix	
			,	
I, 127.54-127.92	limestone, pel-biosparite	low	dense sparite cement	
I, 129.85-130.27	not received			
I, 131.27-131.55	limestone, pel-biosparite	low	dense sparite cement	
I, 133.08-133.41	limestone, pel- biomicrite	low	dense micrite matrix	
I, 134.59-135.01	limestone, oo-pel-biosparite	low	dense sparite cement	
I, 137.61-137.84	limestone, pel-biosparite	low	very dense and fine sparite cement	
I, 138.93-139.31	dolostone, micro sparite	high	large cavities throughout	
I, 142.57-142.87	dolomitic limestone, biomicrite	high	many lg. pores in dolomitized areas	
I, 145.27-145.46	limestone, pelmicrite	low	no visible porosity	
I, 146.63-146.88	limestone, biomicrite	low	dense micrite matrix	

Mr. William Wright July 13, 2000 Page 3

## **Procedures**

Thin section analysis was performed in accordance with APS Standard Operating Procedure 00 LAB 016, "Preparation of Thin Sections for Petrographic Analysis, APS Method". The selected sections of the core samples are first highly polished, then epoxied to a glass slide. The excess sample is cut from the glass and the slide is polished until the material reaches 25 microns or less in thickness. The resulting samples were reviewed under a petrographic microscope at magnifications up to 1000x. Our conclusions are based on the work performed, our observations, and experience. Laboratory testing was performed on June 13, 2000 and subsequent dates. Photos are included to illustrate our conclusions and observations.

## Remarks

The core samples will be retained for a period of at least thirty days from the date of this report. Unless further instructions are received by that time, the sample may be discarded. The geologic services for this project have been conducted in a manner consistent with that level of care and skill exercised by members of the profession currently practicing in this area under similar budget and time constraints. No warranty, express or implied, is made.

If I can be of further assistance to you, please contact me at (651) 659-1346.

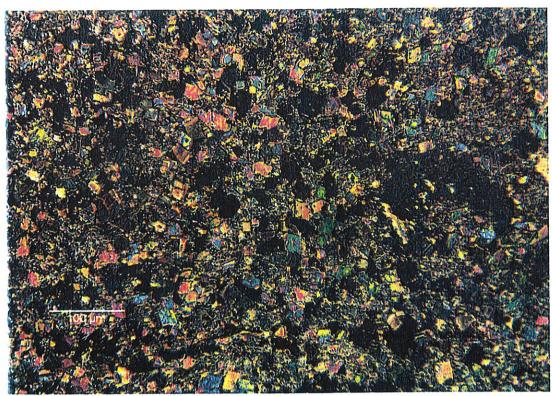
Report Prepared By:

Gerard Moulzolf, Po

Vice President/Geologist/Retrographer

MN License #30023

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000



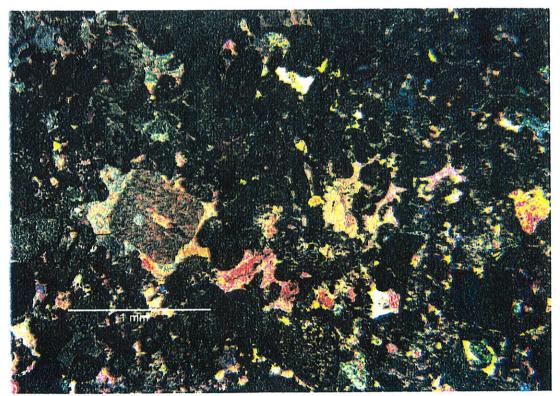
SAMPLE IDENTIFICATION:

G,112.2 -112.46

SAMPLE DESCRIPTION: Dolomitic limestone. Euhedral dolomite rhombs in finer calcite matrix. Some of the black (extinct) areas are voidspace; under cross polarized light.

MAGNIFICATION:

200x

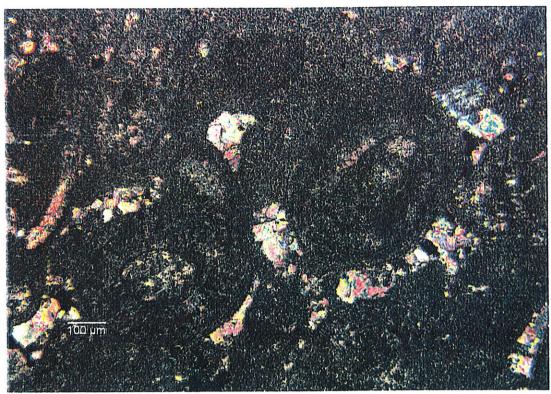


SAMPLE IDENTIFICATION:

G114.74-115.07 SAMPLE DESCRIPTION: Relatively dense pel-biosparite. Drusy sparite cement and syntaxial calcite growth around echinoderm fragments fill intergranular space cross polarized light

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

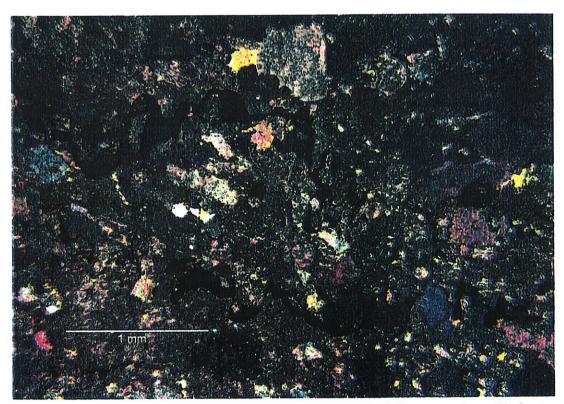


SAMPLE IDENTIFICATION:

G116.11 -116.53 SAMPLE DESCRIPTION: Oo-pel-biosparite. Drusy sparite cement fills intergranular spaces. cross polarized light.

MAGNIFICATION:

100x

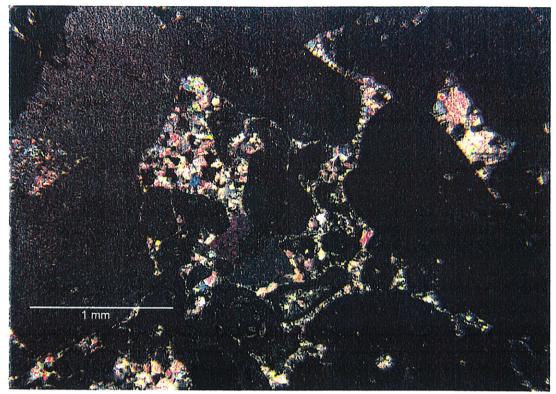


SAMPLE IDENTIFICATION:

G118.36-118.51 SAMPLE DESCRIPTION: Stylolites; appearing as black sutured voidspaces in the oo-pel-biosparite. cross polarized light

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

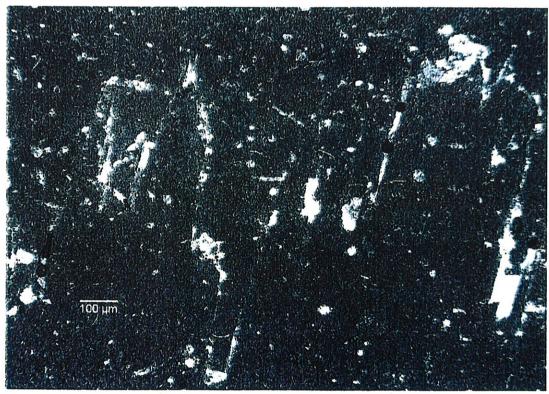


SAMPLE IDENTIFICATION:

G,120.56 -120.89 SAMPLE DESCRIPTION: Pel-biosparite. Drusy sparite cement fills intergranular spaces. cross polarized light.

MAGNIFICATION:

40x

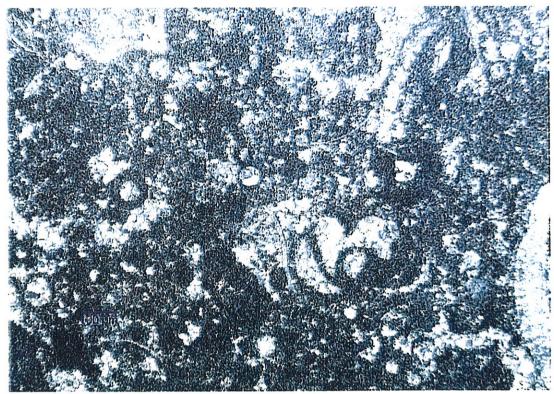


SAMPLE IDENTIFICATION:

G122.41-122.71 SAMPLE DESCRIPTION: Stylolite, sutured white voidspaces in the fine micrite matrix. plane polarized light

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

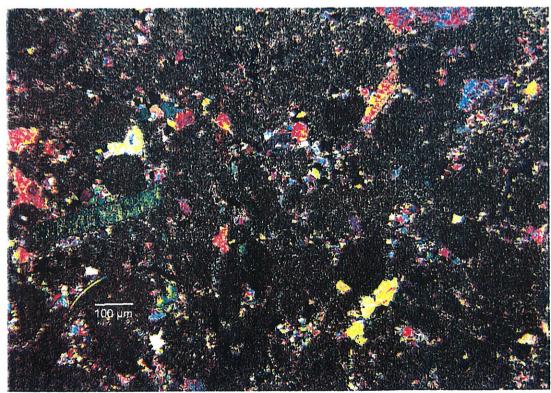


SAMPLE IDENTIFICATION:

G,124.17 -124.46 SAMPLE DESCRIPTION: Oo-pel-biosparite. Drusy sparite cement fills intergranular spaces. plane polarized light.

MAGNIFICATION:

100x



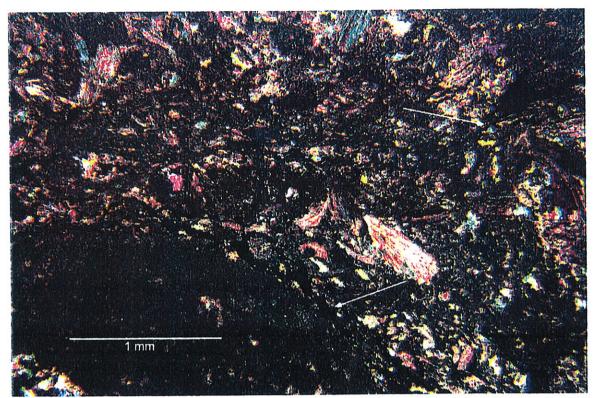
SAMPLE IDENTIFICATION:

G,126.79-127.13 SAMPLE DESCRIPTION: Oo-pel-biosparite. Drusy sparite cement fills intergranular spaces. cross polarized light.

MAGNIFICATION:

DATE: JULY 12, 2000

APS# PROJECT: 10-01078 Solutia, Inc. Sauget Area 1

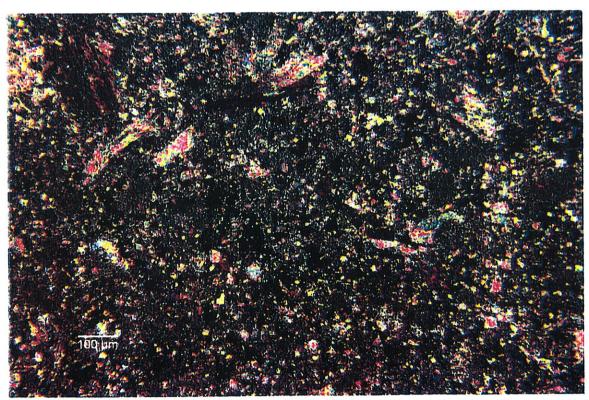


SAMPLE IDENTIFICATION:

G128.42 -128.73 SAMPLE DESCRIPTION: Oo-pel-biosparite. Concentrations of crude stylolite voidspace. cross polarized light.

MAGNIFICATION:

40x

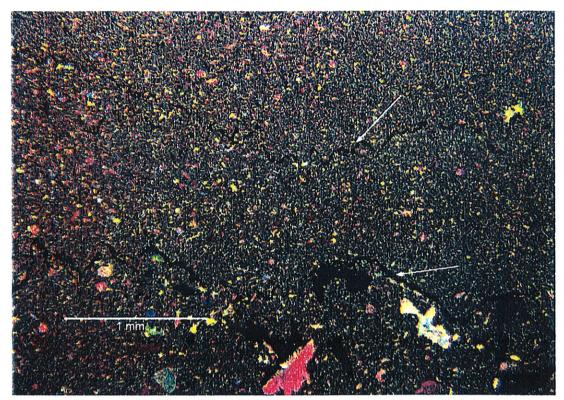


SAMPLE IDENTIFICATION:

G130.80-131.10 SAMPLE DESCRIPTION: Dolomitic limestone. Fine, euhedral dolomite rhombs occur throughout. Moderate porosity. cross polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

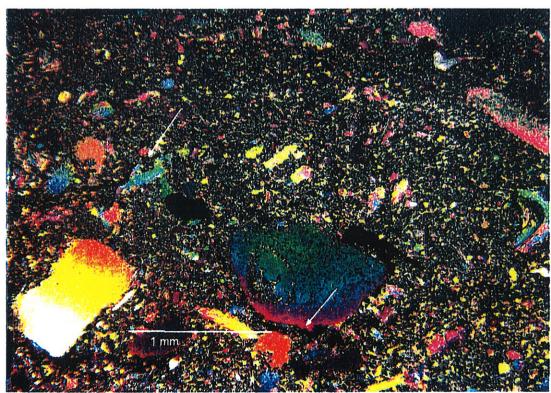


SAMPLE IDENTIFICATION:

H,111.83-112.19 SAMPLE DESCRIPTION: Biosparite. Sutured stylolite voidspace in black under cross polarized light.

MAGNIFICATION:

40x



SAMPLE IDENTIFICATION:

H,113.46-113.81 SAMPLE DESCRIPTION: Biosparite. Crude stylolite voidspace in black under cross polarized light.

MAGNIFICATION:

DATE: JULY 12, 2000

APS# PROJECT: 10-01078 Solutia, Inc. Sauget Area 1



SAMPLE IDENTIFICATION:

H,115.76-116.03 SAMPLE DESCRIPTION: Dolomitic limestone. Porespaces noted by blue arrows. Dolomite appears as euhedral rhombs. plane polarized light.

MAGNIFICATION:

200x

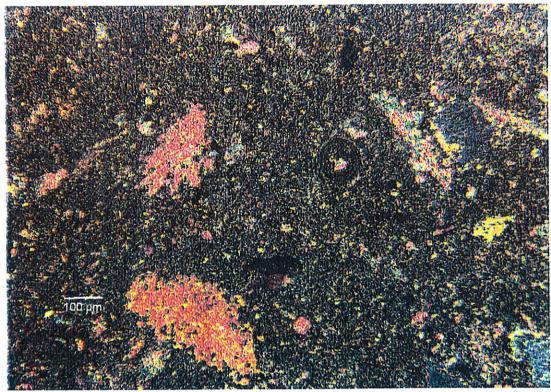


SAMPLE IDENTIFICATION:

H,118.04-118.46 SAMPLE DESCRIPTION: Calcitic dolostone. Porespaces noted by blue arrows. plane polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

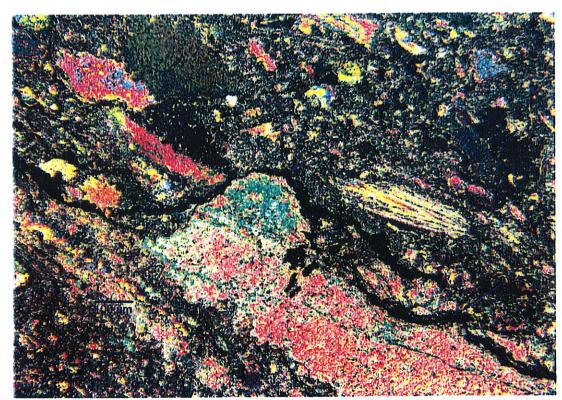


SAMPLE IDENTIFICATION:

H,119.87-120.29 SAMPLE DESCRIPTION: Oo-pel-biosparite. Dense sparite cement. cross polarized light.

MAGNIFICATION:

100x



SAMPLE IDENTIFICATION:

H,121.43-121.63 SAMPLE DESCRIPTION: Biosparite. Stylolite voidspaces noted by blue arrows. cross polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

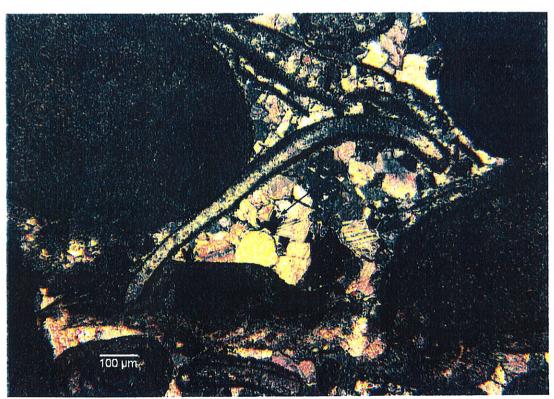


SAMPLE IDENTIFICATION:

H,122.5-122.79 SAMPLE DESCRIPTION: Biosparite. Dense sparite cement surrounding fossil fragments. plane polarized light.

MAGNIFICATION:

100x



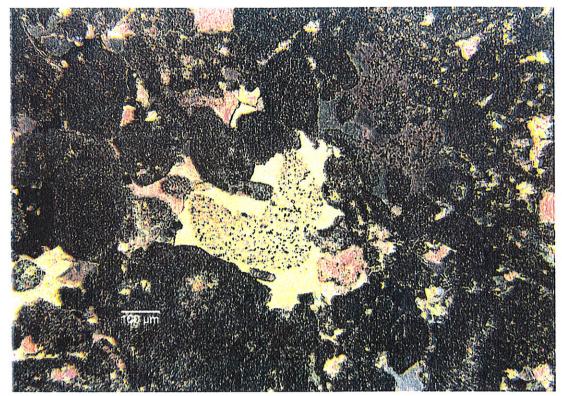
SAMPLE IDENTIFICATION:

H,125.30-125.59 SAMPLE DESCRIPTION: Oo-pel-biosparite. Porespace in drusy sparite cement. cross polarized light.

MAGNIFICATION:

APS# 10 PROJECT: Se

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000



SAMPLE IDENTIFICATION:

H,128.99-129.39 SAMPLE DESCRIPTION: Pel-biosparite. Syntaxial sparite cement growth around echinoderm fragment (center). cross polarized light.

MAGNIFICATION:

100x



SAMPLE IDENTIFICATION:

H,131.04-131.43 SAMPLE DESCRIPTION: Biomicrite. Dense micrite matrix. cross polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

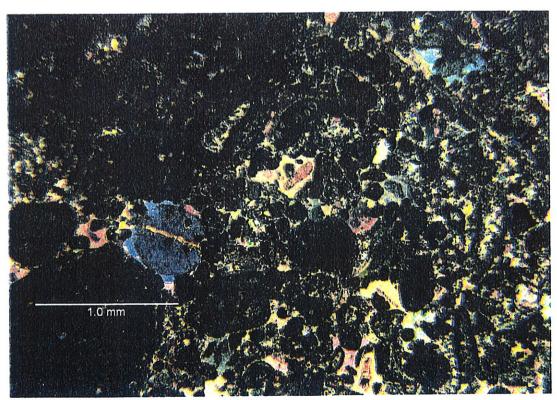


SAMPLE IDENTIFICATION:

I,127.54-127.92 SAMPLE DESCRIPTION: Pel-biosparite. Syntaxial sparite cement growth around echinoderm fragment (center). cross polarized light.

MAGNIFICATION:

100x

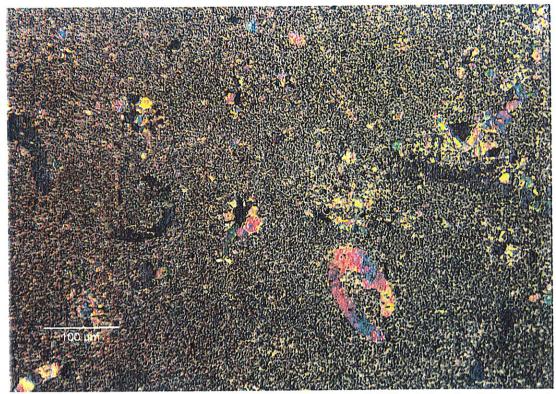


SAMPLE IDENTIFICATION:

I,131.27-131.55 SAMPLE DESCRIPTION: Pel-biosparite. Dense sparite cement. cross polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

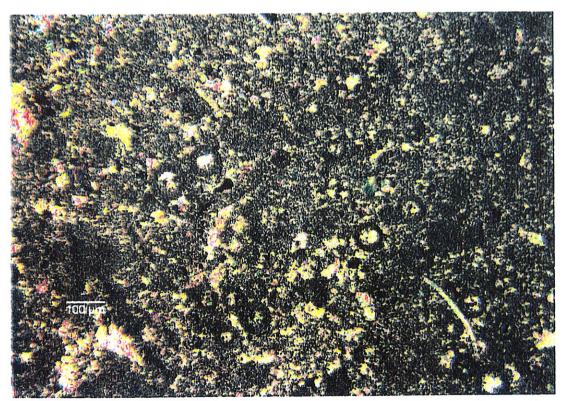


SAMPLE IDENTIFICATION:

I,133.08-133.41 SAMPLE DESCRIPTION: Pel-biomicrite. Fossil fragments in a dense micrite matrix under cross polarized light.

MAGNIFICATION:

200x

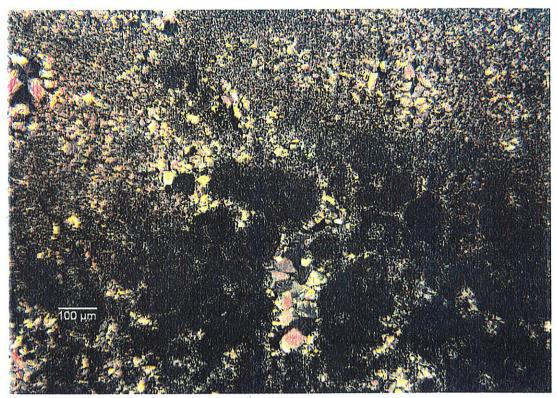


SAMPLE IDENTIFICATION:

I,134.59-135.01 SAMPLE DESCRIPTION: Oo-pel-biosparite. Dense sparite cement. cross polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

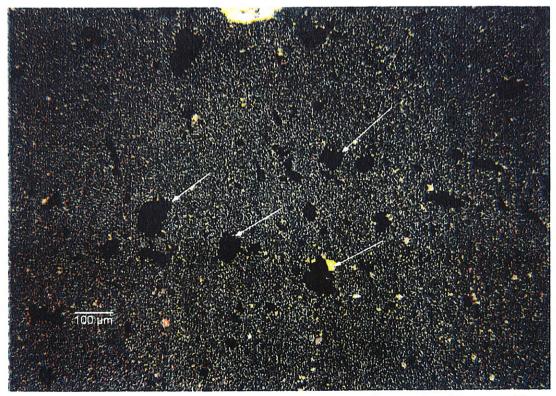


SAMPLE IDENTIFICATION:

I,137.61-137.84 SAMPLE DESCRIPTION: Pel-biosparite. Dense sparite cement under cross polarized light.

MAGNIFICATION:

100x

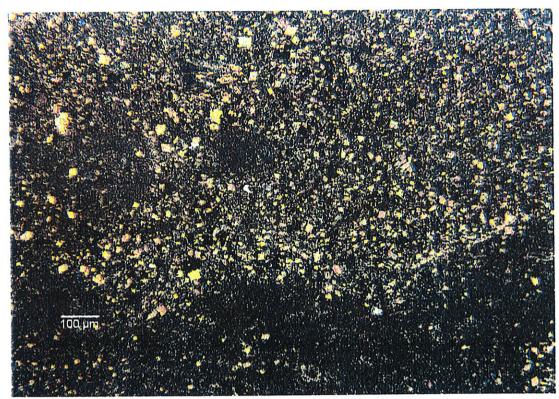


SAMPLE IDENTIFICATION:

I,138.93-139.31 SAMPLE DESCRIPTION: Micro-sparite with many voidspaces which appear black under cross polarized light.

MAGNIFICATION:

10-01078 Solutia, Inc. Sauget Area 1 DATE: JULY 12, 2000

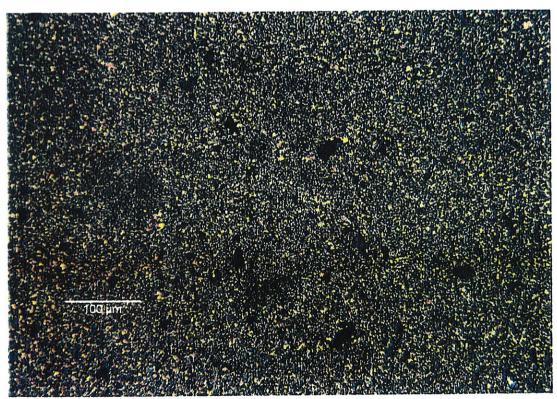


SAMPLE IDENTIFICATION:

I,142.57-142.87 SAMPLE DESCRIPTION: Dolomitic limestone. Black pore space in dolotimized area, under cross polarized light.

MAGNIFICATION:

100x



SAMPLE IDENTIFICATION:

I,145.27-145.46 SAMPLE DESCRIPTION: Pelmicrite under cross polarized light. Some gray colored quartz silt was present. No visable porosity.

MAGNIFICATION:

DATE: JULY 12, 2000

APS# PROJECT: 10-01078 Solutia, Inc. Sauget Area 1



SAMPLE IDENTIFICATION:

I,146.63-146.88 SAMPLE DESCRIPTION: Biomicrite. Dense micrite matrix under cross polarized light.

MAGNIFICATION:



October 12, 2000

O'Brien & Gere Engineers, Inc. 12250 Weber Hill Road St. Louis, MO 63127

Attn: William Wright

Subj.: Solutia, Inc

Sauget Area 1

APS Job No. 10-01262

Dear Mr. Wright:

This letter presents the results of our observation made on one rock core samples. The scope of our work was limited to visually documenting the relative porosity of the selected area within the rock sample by thin section analysis. The sample was submitted by Mr. William Wright of O'Brien & Gere, Inc. on September 26, 2000. Our work was authorized at that time.

# **Observations**

Sample	Lithology	Porosity	Comments
I, 129.85-130.27	Pel - bio sparite	Low	Dense, drusy sparite cement, syntaxial cement growth surrounds fossil fragments

### **Procedures**

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Mr. William Wright October 12, 2000 Page 2

# Remarks

The core sample will be retained for a period of at least thirty days from the date of this report. Unless further instructions are received by that time, the sample may be discarded. The geologic services for this project have been conducted in a manner consistent with that level of care and skill exercised by members of the profession currently practicing in this area under similar budget and time constraints. No warranty, express or implied, is made.

If I can be of further assistance to you, please contact Gerard Moulzolf at (651) 659-1346.

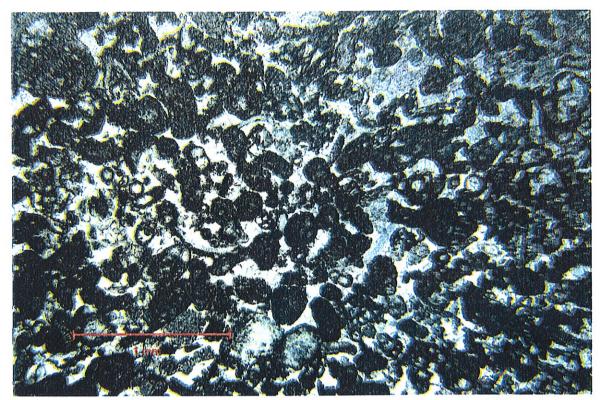
Report Prepared By:

Gerard Moulzolf

Vice President/GeologistXPetrographer

MN License #30023

10-01262 Solutia, Inc. Sauget Area 1 DATE: OCTOBER 12, 2000

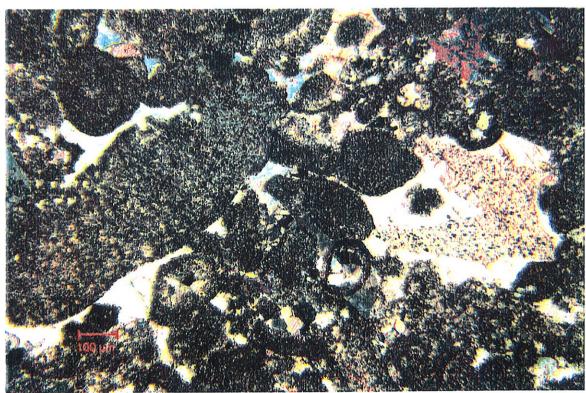


SAMPLE IDENTIFICATION:

I 129.85-130.27 SAMPLE DESCRIPTION: Pel - bio sparite. A thin section under plane polarized light

MAGNIFICATION:

40x



SAMPLE IDENTIFICATION:

I 129.85-130.27 SAMPLE DESCRIPTION: Coarser sparite cement and syntaxial sparite cement fill voids between peloids and fossil fragments. Cross polarized light

MAGNIFICATION: